MECHANICAL ENGINEERING

AUGUST 1947

M.E. FALL MEETING—SALT LAKE CITY, UTAH—SEPTEMBER 1-4, 1947

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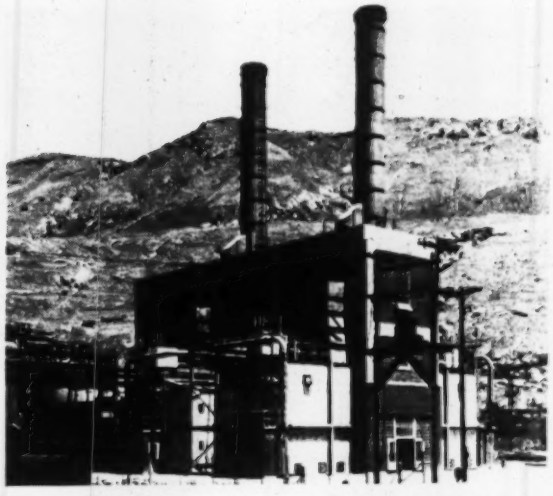

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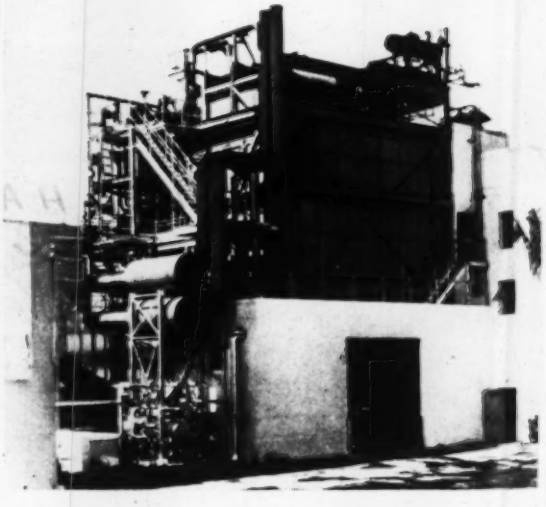

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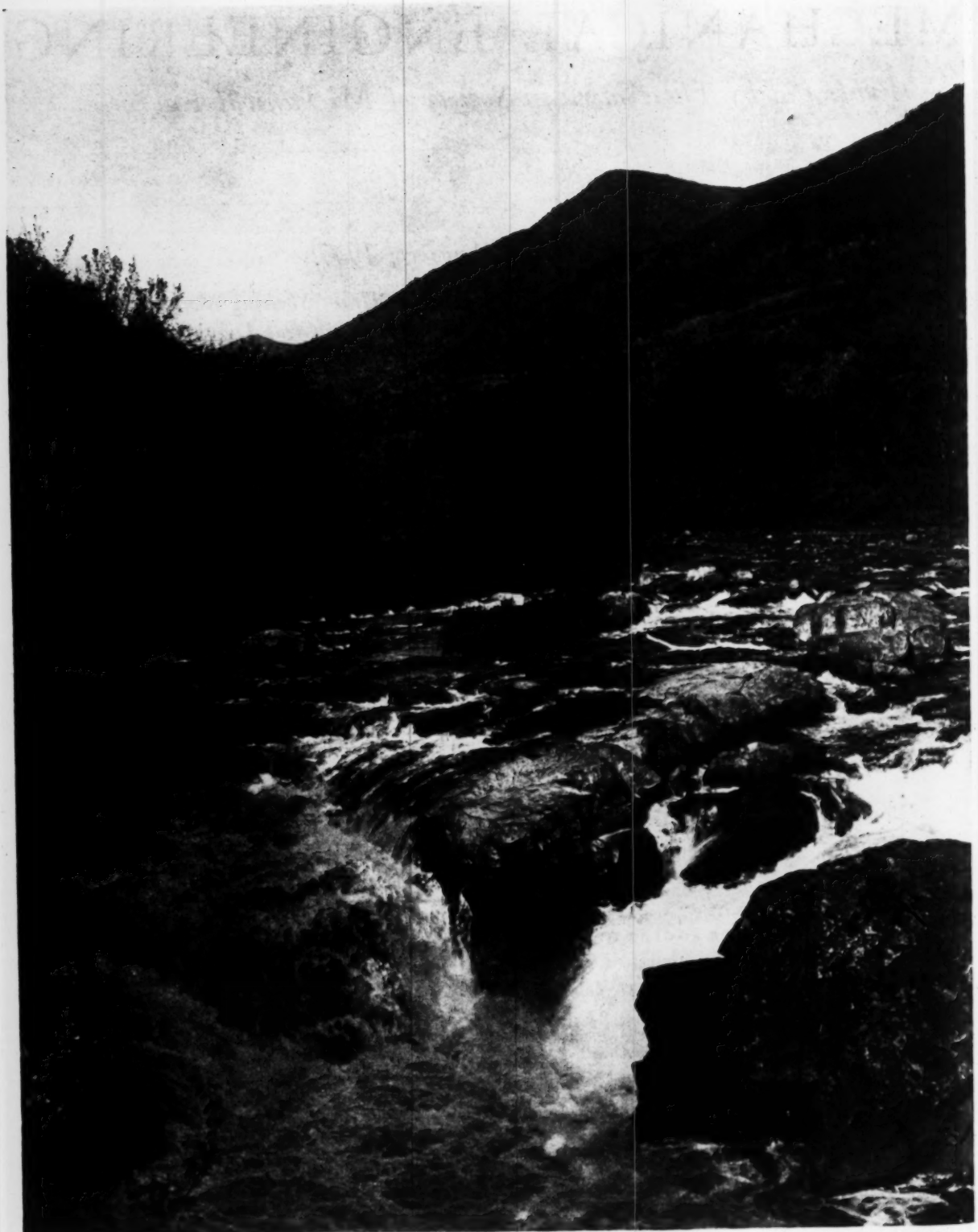

Charles Phelps Cushing

Scene in the Adirondacks

VOLUME 69
No. 8

MECHANICAL ENGINEERING

AUGUST
1947

GEORGE A. STETSON, *Editor*

Engineers' Status

IN 1939 the median salary of an engineer 35 to 39 years out of college was $550 per month, nearly $4^1/_2$ times the median salary of a first-year engineering graduate. In 1946 the engineer with 35 to 39 years' experience was getting $629 per month and the young man $232, a ratio of $2^3/_4$ to 1. These facts come from the 80-page report of the Engineers Joint Council, "The Engineering Profession in Transition," soon to be published, and are based on the 87,000 returns of the questionnaire sent to all engineers during the fall of 1946. A résumé of the report has been prepared by William N. Carey, executive secretary, American Society of Civil Engineers and chairman of the E.J.C. Committee which conducted the E.J.C. 1946 Survey of the Engineering Profession. Colonel Carey's résumé will appear in the September issue of MECHANICAL ENGINEERING.

According to the report the engineering profession in 1946 showed the following percentage distribution: Electrical, 25.2; mechanical-industrial, 23.7; civil, 23.6 chemical, 9.8; mining-metallurgical, 7.6; other engineering, 6.5; and nonengineering, 3.6. For mechanical-industrial engineers the spread of monthly earnings over the experience span, from graduation, of 35 to 39 years was from $225 to $587. Hence for this group the ratio of median earnings of experienced engineers to newcomers is slightly less than $2^3/_4$-to-1 ratio which prevails for all groups. Highest median earnings were reported for chemical engineers—$256 per month for newcomers and $825 for the 35–39 year group, a ratio of 3.2 to 1.

Approximately 12 per cent of the engineers of the nation served in the Armed Forces during World War II, the report shows. The breakdown by groups in percentages of the total is: Civil, 29; mechanical-industrial, 15; electrical, 14.7; chemical, 1.8; mining-metallurgical, 1; other engineering, 14.2; and nonengineering, 24.3. Colonel Carey states that "as to comparative earnings between engineers in the Armed Forces in 1943 and those who were civilians, the survey indicates that base median monthly rates were approximately the same at each respective experience level for the two groups."

Data on the geographical distribution of engineers show that 32.1 per cent are in the states of New York, New Jersey, and Pennsylvania. The next largest number are in the area which includes Ohio, Indiana, Illinois, Michigan, and Wisconsin—20.8 per cent. The three Pacific states contain 11.4 per cent of the total; and the region with the smallest percentage, 3.2, is represented by Kentucky, Tennessee, Mississippi, and Alabama.

The pattern of other information presented by Colonel Carey is much the same as that found in the study of earnings of mechanical engineers that was made by the A.S.M.E. in 1930. Both the E.J.C. 1946 and the A.S.M.E. 1930 studies demonstrate that engineers with a college education earn more than noncollege men as they grow older and that advanced degrees command the higher salaries. Salary differences early in life are not considerable and increases are relatively rapid during the early years of the engineer's career. As engineers gain experience the rate of salary increase lessens and reaches a maximum; followed, in some cases, by a decrease. According to the 1946 study, "really significant differences in engineers' earnings begin to appear only beyond the 8 years' experience span" or at about age 31, and the extent of these differences depends largely on the general field of employment, educational qualifications, and occupational assignment. Earnings of engineers in private employment exceed, in general, those of engineers in public employment, and the differential becomes greater as the span of experience grows longer.

Engineers Work for Peace

PROBABLY no question is giving thoughtful men the world over more concern today than what position the people of the United States will take in respect to world affairs. As a result of the war this nation finds itself in a position to exercise leadership. At present many areas which felt the full impact of the war look to this nation for material aid. Until their economies and in some cases their governments are restored to full effectiveness, many peoples are dependent upon us; and in other cases such efforts as are being made toward reconstruction and resumption of peacetime trade, industry, and way of life, may succeed or fail, depending on the position we take. The role in which we are now cast is new to us. Its responsibilities bear heavily on us, and success in it depends upon a unity of purpose and policy. More than ever before our internal as well as our foreign policies and our success in making them work will affect the rest of the world. With the exception of war itself, the nations of the world fear more than anything else indifference or imperialism on our part in world affairs and economic instability within our own borders.

The engineers' share in these responsibilities is a heavy one. First, as good citizens, they must align themselves with the forces which make for peace and opportunity for normal development throughout the world. But in a larger sense they are in a position to work effectively

toward the ends that are desired by all peace-loving peoples.

It has been pointed out time and again that democracy, if it is to be embraced by peoples who have never enjoyed its advantages, must be made effective in all lands where citizens profess to practice it. In local as well as national government, in the shop as well as in the home and the school, the ideals of democracy must be sustained and preached and these ideals must be put into effective action. As individuals and as groups, engineers are close to the mechanisms by which modern society is affected in an age of technology. To leave decisions on matters of public importance to men, no matter how honest and well-intentioned they may be, who do not properly understand them is to shirk a duty which special knowledge and training impose. While cases of engineers in government are not numerous there are encouraging signs that more engineers are seeking and being elected to public office. Many of the highly technical functions of government on all levels, national, state, and local, are actually carried out by engineers in the civil service, and the record is a good one in general.

On the industrial front, where large numbers of engineers hold key posts as managers and administrators, the responsibility is particularly great and the opportunity for making democracy work, for developing national unity in support of our way of life, and for maintaining high levels of production and smoothly efficient operation of transportation and communication, is ever present. Successful operation of our domestic productive economy will be a powerful factor in tempting other nations to set up and maintain the democratic way of life. No small part of this industrial managerial problem lies in the field of industrial relations. Although the solution to labor troubles may be aided by legislation, many of the causes lie in areas where patience, fair dealing, and mutual trust and understanding are more effective. The engineer manager is making progress in this field, but it is important that this progress be accelerated.

As professional men engineers also have an opportunity to make democracy effective and a way of life to be desired by peoples who have never enjoyed freedom. Most engineering societies devote some portion of their energies to the task of inspiring their members to take the larger view of their responsibilities and, singly or as groups, to work toward the end of improving economic and social conditions. When national security demanded all-out production and the development of devices to insure victory, engineers responded wholeheartedly and their national societies devoted most of their energies toward that end. Joint action in national and international affairs is present evidence of the desire of engineering societies to make themselves fully effective in the postwar world. A committee of the Engineers Joint Council prepared reports many months ago on the disarmament of Germany and Japan; and the recommendations made in these reports were gratefully acknowledged by military government officials. The Committee on International Relations of E.J.C. has been carrying forward a program of aid to engineers in other nations, moved not only by concern for their fellows but also by recognition of the fact that in the postwar role of the United States in world affairs engineers must assume their full share of the burden.

Current conditions demand a full measure of faith in democracy, a will to make it work at home, a desire to spread its benefits to all nations willing to accept its responsibilities, frank and generous dealings with peoples here and abroad, and a policy of national action which is free from suspicion of exploitation or tyrannical domination, and so soundly based and administered that unity and economic and social stability are achieved in the United States and an alertness to safeguard national interests is constantly maintained. Without underestimating powerful factors in political, economic, social, and spiritual realms which influence the course of world affairs, it must be admitted that modern technology, the field in which engineers are supreme, is of ever-growing importance. It is in this field that the engineers have competence. Using this competence wisely, engineers may effectively work for peace.

UNESCO

ONE field of international affairs in which engineers will have an opportunity jointly to play an important part is in the United States National Commission for UNESCO—the United Nations Educational, Scientific, and Cultural Organization. According to the announcement made on May 9 by Dr. Milton S. Eisenhower, chairman of the Commission, the Engineers Joint Council, which is made up of the presidents in office, junior past-presidents, and secretaries of the Founder Societies and the Institute of Chemical Engineers, will be invited to name a representative to the Commission. The duties of the Commission are to advise the United States Government on UNESCO matters and to bring about widespread national co-operation in UNESCO programs. This invitation is encouraging evidence of the growing recognition engineers and engineering societies are being accorded in the postwar world.

The representative of E.J.C. on the U. S. National Commission on UNESCO will have, in a consultative and advisory capacity, the services of a recently constituted five-man committee known as the Consultative Committee to the Committee on International Relations. This new committee was formed at the request of the State Department for the purpose of acting as a consultative and advisory group to the State Department as and when requested. Members of the committee have already been named and include one member of each of the constituent societies of E.J.C. The members are: E. M. Hastings, president of the American Society of Civil Engineers; Clyde Williams, president of the American Institute of Mining and Metallurgical Engineers; D. Robert Yarnall, past-president of The American Society of Mechanical Engineers; W. E. Wickenden, past-president of the American Institute of Electrical Engineers; and J. G. Vail, past-president of the American Institute of Chemical Engineers.

INVESTIGATION OF EXPLOSIONS

Story of an Actual Case and Description of Engineering Method of Analysis Used to Determine Cause

By CROSBY FIELD

COLONEL, ORDNANCE DEPARTMENT RESERVES, U.S.A., FELLOW A.S.M.E.

IN a most desolate northern portion of the Great American Desert, the United States Government established an ammunition storage depot and built 1000 magazines of the igloo type shown in Fig. 1.

One night in the early spring while the weather was still cold, two trucks were standing outside the open door of one of these igloos. One truck, an International, hereinafter called the van, was loaded with bombs. The igloo faced due north and the truck loaded with bombs was close to the open door so that it too faced due north. The other truck, a Ford, was facing northeast by east. It carried roller-conveyer belts and similar accessories. It was also the truck in which the crew traveled to and from the igloos and hence it was called the crew truck.

The procedure in unloading bombs from the van was to advance a fork lift truck from inside the igloo through the door, project its forks under two bombs in the van as shown in Fig. 2, raise the bombs, and then back it away from the van, at the same time turning it so that the forks faced the rear of the igloo. The lift truck then approached the pile already made in the rear of the igloo and raised its forks the required amount, so that the bombs could be placed on the top of the pile. Two men were there to help guide the bomb.

NO SURVIVORS TO TELL WHAT HAPPENED

Six persons were in the vicinity of the igloo at the time of the explosion. Inside the igloo were four persons: one man driving the fork lift; two men on top of the pile guiding the bombs; and the fourth man preparing the dunnage and placing it on the pile before the bombs as they were placed. Outside and in front of the door of the igloo were the driver of the van, whose job it was to assist in guiding the bombs onto the forks of the fork lift truck, and a young woman who normally worked on a loading dock some distance away but with the same crew. The crew was ahead of its schedule and as the night was cold the young woman had remained in the crew-truck seat apparently to keep warm.

At about 9:30 there was a single devastating explosion. The six persons at the igloo were instantly killed and the only witnesses were more than three quarters of a mile from the igloo. Witnesses to the north saw a very intense and vivid white flash, described by them as being "like a flash of heat lightning," which spread in a horizontal direction due north from the igloo. This flash was followed within the second by a red glow which rose from the igloo, reached a height of several hundred feet, and then gradually decreased in size and disappeared. The red glow was compared by one of the witnesses to the appearance of glowing coals in a coal fire. For a brief instant, near its beginning, the glow was accompanied by either smoke or dust. After the disappearance of the red glow there was no further visual sign of the explosion. The total time elapsed was less than one minute.

The foregoing phenomena were witnessed by approximately a score of persons at different places in the area at the time of the explosion. On all essential facts there was complete agreement. The author never before met a group of witnesses who saw an accident and were able to describe it without additions in so accurate a fashion. Their estimates of time were remarkable. Calculations indicate that the time intervals they reported

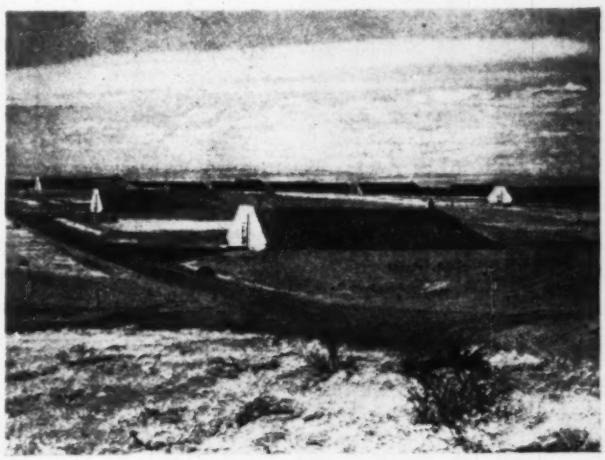

FIG. 1 IGLOOS IN AN AMMUNITION DEPOT
(The explosion described in this article took place in one of these igloos.)

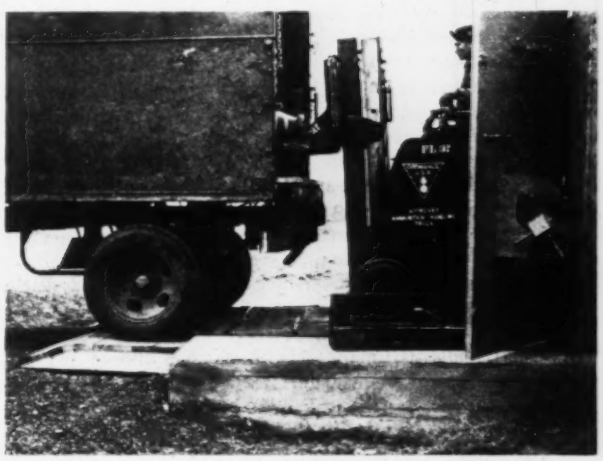

FIG. 2 FORK LIFT TRUCK IS TAKING BOMBS FROM A VAN PREPARATORY TO CARRYING THEM INTO THE IGLOO FOR STORAGE

Based on a forthcoming book to be published by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Acknowledgment is made to *Chemical Engineering* for part of the material originally published in that magazine.

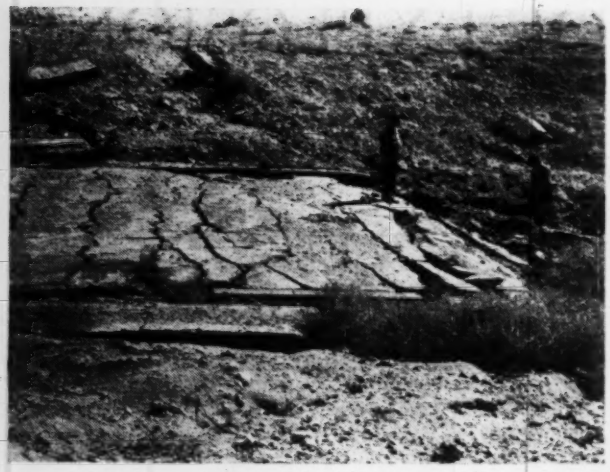

FIG. 3 THE FLOOR OF THE IGLOO AND THE CRATER FORMED BY THE EXPLOSION

FIG. 4 THE CRATER FORMED BY THE EXPLOSION IN THE IGLOO

between seeing and hearing or feeling the resultant concussion check closely with the theoretical time intervals.

All witnesses north of the explosion saw a vivid white "lightning" flash. No witnesses to the south saw this flash but only the red glow.

After this one explosion and after the red glow from it had disappeared, all was quiet. The wind blew, the tumbleweed rolled, and those who approached the scene found only what is shown in Figs. 3, 4, and 5. A thorough study was made, and thanks to prompt action by the Army's commanding officer present, nothing was disturbed until the arrival of the investigators. After the first vain search for survivors a few pieces of human remains were picked up and preserved and the investigation procedure began to grind out its results.

FIG. 5 ANOTHER VIEW OF THE CRATER AT THE REAR OF THE IGLOO

MAPPING THE MISSILES

As usual, "missile" maps, one of which is shown in Fig. 6, were made to show the locations of the fragments of wreckage. In this particular case the task was accomplished at reasonable cost by a group of laborers who marched up and down the area and placed stakes where any object was found. Then followed a surveying party of three, comprising a rodman, a recorder, and an expert on automotive parts. A surveyor with a transit was placed on top of one of the neighboring igloos, and by stadia measurements, the missile locations were rapidly plotted.

As the investigation proceeded it became apparent that the fork lift truck was very close to the explosion and all parts of this truck that could be recovered, Fig. 7, were taken into a warehouse and studied. Of these various parts the most informative were the backplate pieces, Fig. 8, and the two parts of the mechanism shown in Fig. 9.

For two parts of the truck mechanism to have been pierced by the same fragment, as appeared likely, they would have had to have been in the position shown in Fig. 10. That these pieces were in such a position at the time of the explosion was confirmed by the fact that the pieces of equipment behind the crosspiece part that were covered or protected by it showed no signs of flash burning, whereas those parts which were not so protected showed signs of burning.

If these parts were in the position shown in Fig. 10, then the fork lift at the moment of the explosion was raised to the position shown in Fig. 11. This is the height to which the fork lift would have been raised if the last bomb of the van load were being put into its proper place on the pile of bombs at the rear of the igloo. This statement can be made because it is known that the crew followed a standard loading diagram. No bombs were found nor was there a crater under the van at the door. It is believed therefore that all the bombs had been removed from the van and that the fork lift was placing the last one or two bombs on the pile at the rear of the igloo at the moment of the explosion.

A further study was made of the fork-lift pieces as shown in the missile map of Fig. 6. As will be noted, the dotted lines or radii include between them all parts of the fork lift except the very light pieces 87, 111, and 121, the trajectories of which are uncertain because of their large surfaces and lightweight.

A study of the other parts of the fork lift found within these two radii showed that all parts belonging to the same "family" lay within pairs of radii which, when projected, intersected within a circle one foot in radius, the center of which was the intersection of the two dotted lines on the missile chart, Fig. 6. This intersection therefore is the approximate point of origin of the trajectories of the fork-lift parts, and the radial line from this point to any missile fragment is the horizontal projection of its trajectory.

This center was 20 ft north of the rear wall of the igloo and 8 ft

east of the west wall. This is exactly the position in which the fork lift would have been had it been placing the last bombs from the truck on the pile according to the standard loading diagram.

No parts of the bodies of any of the four persons who were inside the igloo were ever recovered. The parts of the man's body that were found, when analyzed by the method that was used in studying other missiles, indicated that he was at the tailboard of the van at the moment of the explosion, possibly raising the tailboard preparatory to leaving. Similarly, the parts of the girl's body, by their appearance and location, indicated that she was seated or slumped in the seat of the truck.

Colored photographs were taken at night of a detonation of a small amount of composition B. These indicate that at the moment of the explosion an intense white light is followed by a red flash. The white flash noted by the witnesses was undoubtedly intensified by the molten metal of the bombs that were propelled through the air at a high rate of speed. Calculations indicate that the initial speed of these fragments was between 8000 and 10,000 fps. The fact that no other white flash was seen indicates that there was one explosion. Witnesses who were north of the igloo saw the white flash because the explosion occurred within the igloo, the door of which was on the north side. The explosion was screened by the side and roof of the igloo from observers in other directions.

All of the 70 tons of bombs exploded. Of the 35 tons of composition B explosive not a trace was found unburned. A very small amount of the 35 tons of metal in the bombs was found.

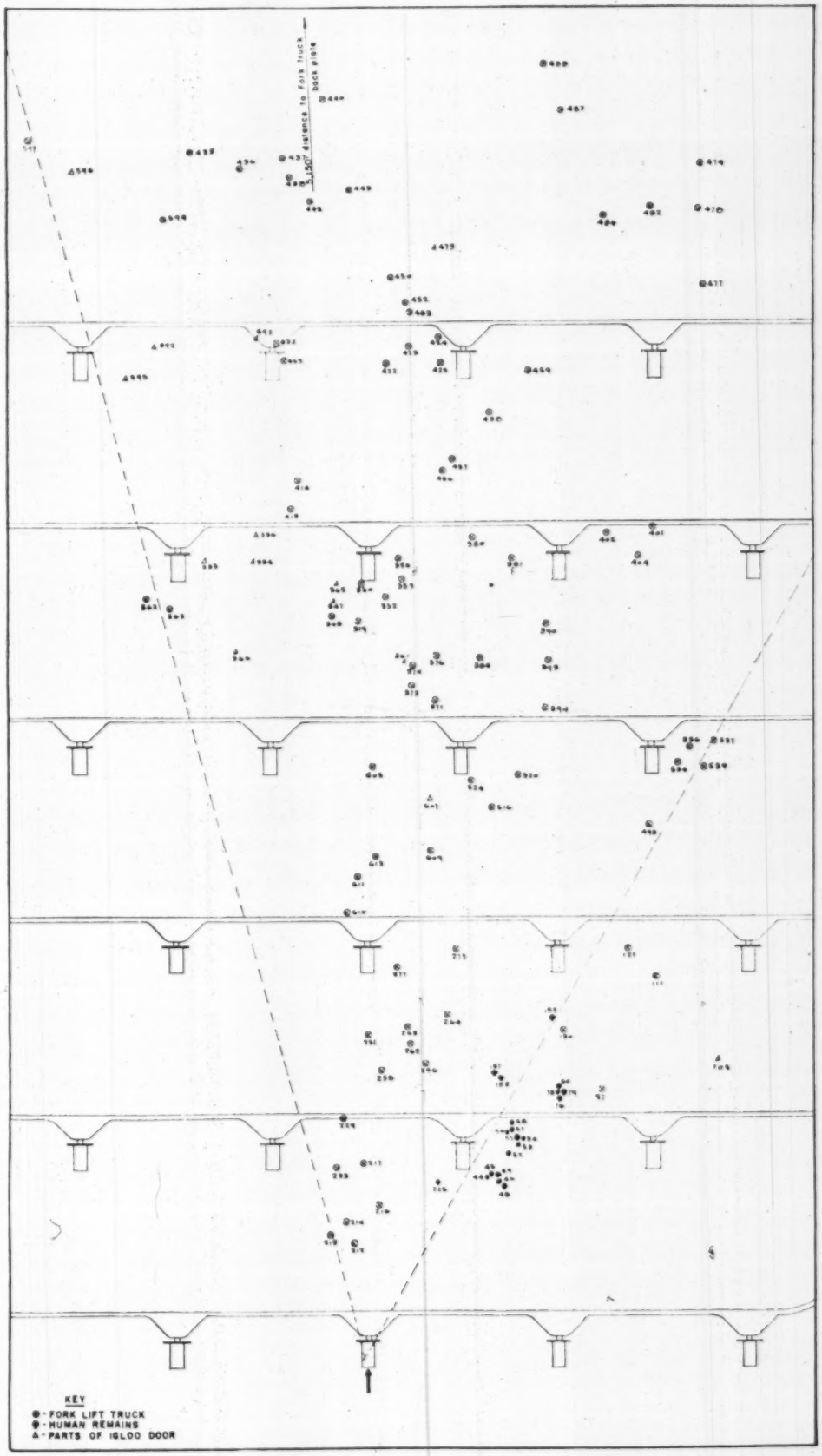

FIG. 6 MISSILE MAP OF THE IGLOO EXPLOSION SHOWING LOCATIONS OF FRAGMENTS OF FORK LIFT TRUCK, IGLOO DOOR, AND HUMAN REMAINS; ARROW AT BOTTOM SHOWS LOCATION OF IGLOO

FIG. 7 ALL THAT COULD BE FOUND OF THE FORK LIFT TRUCK

FIG. 8 TELLTALE BACKPLATE OF THE FORK LIFT TRUCK
(Burning of the metal and imprints of fragments gave confirming evidence of the cause of the explosion.)

INTERESTING FEATURES OF THE EXPLOSION

An interesting feature of this explosion was the extreme heat generated. Practically all of the bomb fragments showed signs of intense burning and all recovered bomb fragments were small in size, with no sharp edges. The majority of the bomb fragments apparently completely vaporized, because out of the thirty-five tons of metal less than a ton was recovered. All stones and concrete directly under the stack of bombs were heated so intensely that they disintegrated upon a slight tap. This disintegration extended approximately 10 ft from the edge of the remaining floor toward the front of the igloo. From this line to the north (door) side of the igloo the concrete remained firm, except for the transverse cracks shown in the photographs, and bore only surface marks to show the effect of the blast.

A portion of ground directly under the bomb stack was warm to the touch three days after the explosion to a distance of approximately 8 ft below the floor. It was so warm that as it was being excavated smoke or vapor arose, but it is interesting to note that no considerable quantity of hot or cold metal could be found. In the entire area under the crater less than 20 lb of bomb fragments was recovered. The only other metal recovered from the interior of the igloo, except reinforcing rod embedded in the concrete, was a small piece, approximately 2 in. wide and 4 in. long, of the top of the cover of the battery compartment of the fork lift truck. All material in this crater was thoroughly screened.

All adjacent igloos were thoroughly inspected and no indications were found that these had been affected in any way by the explosion. There were no fallen concrete chips or dust, and the lading had the appearance of not having been moved. The only effect on any igloo was that produced by a flying piece of plate of the fork lift truck which landed on the top of an igloo, 4900 ft from the igloo that exploded. This piece cut a hole in the earth covering and destroyed the concrete base of the lightning rod and then continued on its way to a point 5150 ft from the door of the exploding igloo.

Following are the wide-flung missiles:

(*a*) Part of fork-lift backplate weighing 203½ lb, 5000 ft in a northerly direction.

(*b*) The other part of the backplate weighing 160 lb, 5000 ft.

(*c*) The steering assembly weighing 296 lb, 1660 ft.

(*d*) Concrete block from east wall weighing approximately 1500 lb, which hit at 1780 ft and then slid 20 ft.

It will be noted that the igloo faced almost due north and the missiles were thrown approximately 5000 ft north and 2000 ft east and west, respectively, but that no missiles were found more than 1200 ft south. Sand from the disintegrated concrete was blown four miles east-northeast, and a small piece of concrete was allegedly picked up by a farmer 4½ miles from the igloo that exploded.

Another curious feature of this explosion was the fact that the sound was not great. One witness, who had had experience in mining, stated that the main explosion resembled the setting off of a deep mine-shaft blast. A similar description was given by other witnesses. Many of the witnesses a mile or so away heard nothing but sensed the explosion from the "feel" of the ground or the truck in which they were riding. One witness received an impulse in the ear, which "started to ache" from it, but she felt little jar.

In the conduct of the investigation certain tests were run. For example, at 9:30 one night, a witness, who had seen the igloo explosion from the window of his home, was taken approximately the same distance and in approximately the same direction from an empty igloo. In this igloo welding arcs as high as 350 amp were drawn on steel. The witness stated that the effect was the same as that of the white flash he had seen from the explosion, but very faint in comparison therewith.

A 1000-watt electric light was purposely broken and burned for seven seconds in the air before extinguishing itself. Next, a cable from the portable lighting plant was short-circuited by a metal plate. It was found that the light cable would burn itself up without blowing a 30-amp fuse but would blow a 20-amp fuse when completely shorted.

WHAT MUST HAVE HAPPENED

As usual in an investigation of this nature, it was necessary to obtain data by tests or otherwise to disprove many hypotheses as to the cause of the explosion.

The conclusion was either that the fork of the fork lift truck in moving had struck one of the bombs on its tail, or, what was more likely, that one of the bombs being placed on the pile fell on its tail. This could easily have happened if the fork lift had moved away from the pile too suddenly. It would have taken the bomb back with it and the bomb would have fallen approximately 5 ft directly on its tail.

That bombs have been dropped under similar conditions was

FIG. 9 TWO PIECES OF THE FORK-LIFT-TRUCK OPERATING MECHANISM

(Holes in piece No. 1, tilt-arm rocker shaft, and No. 2, upright telescopic support spacer, were made by the same missile. See Fig 10.)

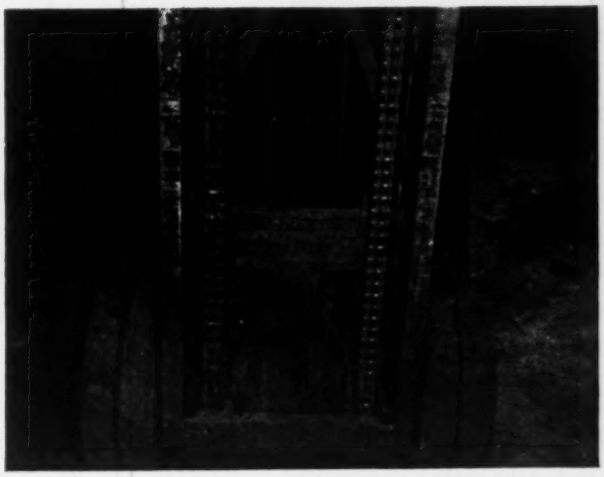

FIG. 10 FRONT VIEW OF A FORK LIFT TRUCK SIMILAR TO THE ONE INVOLVED IN THE EXPLOSION

(No. 1 is the tilt-arm rocker shaft and No. 2 the upright telescopic support spacer.)

proved to have been a fact. It seemed incredible, however, that a type of bomb which had been dropped 2000 ft on its nose without an explosion, would have exploded if dropped on its tail.

Because of the definite indications from this investigation that the bomb had been dropped 5 ft on its tail and that it had exploded, a long series of investigations was made to demonstrate that such an explosion could occur. As a result of this further study, modifications in the method of filling the shell with explosive were made to remove this cause of accidental detonation.

In the meantime unfortunate accidents abroad in the handling of bombs have been reported which confirm absolutely the fact that a bomb loaded in the manner in which these bombs were loaded and dropped on its tail from a height of even less than 5 ft could detonate.

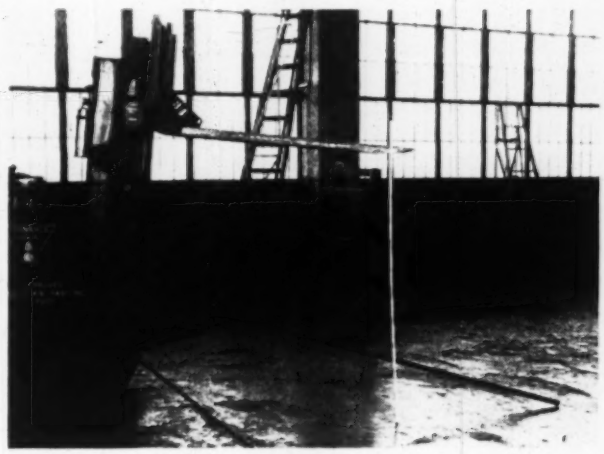

FIG. 11 SIDE VIEW OF FORK LIFT TRUCK SIMILAR TO THE ONE INVOLVED IN THE EXPLOSION

(The fork lift has been raised to a position which brings pieces Nos. 1 and 2, see Figs. 9 and 10, in relative position they must have been in at the time of the explosion.)

It is known of course that even with this sensitivity many thousands of bombs could be dropped without an explosion. Inevitably, however, one out of many hundred would sooner or later be found which would explode with most disastrous results. This is what happened, not only in the igloo explosion described but in several airfields and ammunition depots abroad.

Had the study which led to the change in the method of loading not been made after the investigation of this explosion, a great many more deaths would have occurred from this cause, which undoubtedly would have gone down as one of the unsolved mysteries of the war. By taking advantage of the opportunity of studying carefully the scene of this explosion in this ammunition storage depot, the cause was determined and the cure applied in time to save an untold number of lives, including some of our fighting men abroad who handled these bombs.

METHODS USED IN STUDYING IGLOO EXPLOSION

The foregoing account of a disastrous explosion and the description of the methods by which trained investigators of the Ordnance Department reconstructed in detail what must have happened and arrived at a conclusion as to the cause have been presented in order to convince the reader that accidents of this character can be studied with fruitful results. In the case just described eyewitness testimony was confined to the obvious fact that an explosion must have taken place, and a superficial examination of the wreckage would convince an untrained person that the actual cause would forever remain an unsolved mystery. But, as it was pointed out in discussing this case, if the cause had not been determined, changes in the design of bombs to eliminate possibility of detonation when they were accidentally dropped tailfirst might never have been made and more mysterious accidents, with attendant loss of lives and property, would have been experienced.

As is the case in other problems, an engineering method of analysis can be applied to the investigation of accidental explosions, as illustrated in the one just described. Such a method of analysis was developed during the war by the Safety and Security Branch of the Ordnance Department.[1] It was by

[1] For a description of the organization of the Safety and Security Branch of the Ordnance Department, the objectives and duties of the Safety Section, and a discussion of safety requirements for the manufacture, handling, and transportation of explosives, see "Safety in Army Ordnance Establishments," by Colonel Crosby Field, MECHANICAL ENGINEERING, vol. 65, no. 5, 1943, pp. 353–359.

intelligently and patiently applying this method that investigators of that Branch discovered the cause of the storage igloo explosion which was only one of the great number of baffling cases they were able to solve. The effectiveness of their work was proved by the fact that never during the war was an explosion duplicated. Finding the cause in each case made it possible to safeguard successfully against its recurrence, not only in the plant where the original explosion took place but in all other plants where similar conditions existed.

The measure of success achieved by the Safety and Security Branch of the Ordnance Department may be summarized by saying that the accident frequency rate of more than 15 disabling accidents per million man-hours of exposure in 1941 was reduced to 4. (The annual report of the Division, dated June 30, 1945, states, "The afore-mentioned accident frequency rate represents an all-time low for the Ordnance Department Further, the rate for *Government owned establishments is the lowest for all American manufacturing industries.*" The average for all industries remains quite steadily at about the 15 mark.)

It is curious to note that 95 per cent of the "incidents" in these explosive plants were just the ordinary industrial accidents met in any manufacturing plant—2 per cent were fires and explosions and 3 per cent were injuries from toxic or other chemically produced effects of the materials being handled.

Another way of presenting these facts is that during World War I, 240 lives were lost for every billion pounds of powder and explosives processed. In World War II this figure was reduced to 5. The difference represents more than 10,000 lives saved and a billion dollars worth of Ordnance plants which remained in full operation; but what was most important, our troops had the ammunition when it was most critically needed.

CAUSES OF ACCIDENTAL EXPLOSIONS DIFFICULT TO DETERMINE

In the last analysis, the development of safeguards and protective devices is based fundamentally on the study of past accidents, as has been pointed out in the story of the igloo explosion. The great difference between ordinary industrial accidents and the accidents in explosive plants is that in the former it is relatively easy to reconstruct the scene of the accident and to replace all the material and frequently the personnel just as they were before the accident occurred, and thus review the actual happenings with a minimum of imaginative effort.

In a large explosion so much of the original plant and machinery has completely disappeared and the remainder has become so minutely fragmented and scattered that a physical reconstruction of the plant is in most cases impossible. Fortunately, blueprints and similar plants provide the background against which a reconstruction of the accident can be imagined.

Another difference arises in that the eyewitnesses nearest to the beginning of the explosion are almost always killed, as in the case of the igloo explosion, and those who are further away are rarely in a position to give reliable testimony because of the rapidity of the sequence of events and the extreme shock. The important part of an explosion comprises events occurring all within a fraction of a second although the actual progress of the explosion may last a minute or more.

Eyewitness testimony therefore is of most use in giving a picture of the general conditions of the plant and apparatus, the normal manufacturing procedure, and unusual circumstances such as fire which may have started the chain of events leading to the explosions and which had been under way for a sufficient time to have become truthfully fixed in the minds of the eyewitnesses.

RELIANCE PLACED ON COMPLETE STUDY OF FRAGMENTS OR MISSILES

The investigation of explosions in the past has developed adequate procedures and competent investigators. The advantage marked by the method used by the Ordnance Department is more one of completeness than of uniqueness.[2] It is based upon the observation that the effects of any explosion follow certain well-recognized patterns and the principal difference between large-quantity explosions and small quantity explosions is the difference in size of the various zones in the same pattern. Thus the theory that after an explosion so much is destroyed that the determination of the cause must remain insolvable is rarely true because the zones merely expand or contract in size, the pattern of the zones remaining the same. Each zone in turn is determined by the more intense adjacent zone nearer the explosion.

The method described in this article is thorough. Every obtainable fragment or missile is studied promptly after the explosion. Every missile bears marks giving the story of what it did during the explosion. Some of these missiles will tell much; others have a story of little value provided their testimony does not negate the final conclusion. A few missiles tell a great deal and are properly termed "telltale missiles." In the accidental explosion described in the first part of this paper, the pieces of the fork lift truck were telltale missiles.

It has already been demonstrated in the story of the igloo case that a complete study of the missiles resulting from accidental explosions of military high explosives yields much information as to the cause of such an explosion, where it originated, and the progress of its propagation. In many cases, as in this one, it is the sole source of such information. In cases where eyewitnesses are available, it affords a basis for screening their stories. When discrepancies arise between the stories of eyewitnesses and the conclusions forced by a *complete* missile study, the latter will usually prove correct. This statement is made as the result of the study of a score of explosions, but it presupposes the presence of a sufficient quantity of undisturbed missiles to make possible their complete study, as described in this article. Unlike eyewitnesses, missiles do not change their stories, and if the investigator has made a complete study and the quantity of important missiles has been large enough, he should never have to change his conclusions based upon the story as told by the missiles.

A complete study requires a great amount of time and effort. It is consequently relatively expensive. Its justification lies in the fact that successful determination of the cause of the explosion is usually made and hence it becomes possible to eliminate that hazard in similar circumstances or at least to reduce the probability of exposure to it. Certainty of knowledge as to cause justifies a much higher cost to prevent recurrence than is the case where the cause is in doubt.

The cost of such an investigation depends upon unpredictable circumstances. The number and size of craters and the need for excavating them, the type of terrain, the kind and amount of explosive involved, the character of construction of the equipment and buildings involved, the presence of fire or unexploded explosive, the kind of weather during the investigation, and many other factors, all have a bearing on the cost. The shortest investigation of this type made by the author was one day; the longest, two weeks. During the latter investigation he was assisted at times by as many as fifty men and women supervised by his three full-time well-trained assistants.

The author appreciates the fact that the study of missiles is not new in the investigation of disastrous explosions. In the past, however, it was customary for the investigator to search for what he thought were pertinent missiles. Having found and examined them, he then endeavored to determine from them the cause of the explosion.

[2] In no literature nor prior Ordnance Department report, however, has the author been able to find any record of the valuable innovation of study of missile trajectories and force diagrams nor the use of the V indicator.

The novelty in the procedure that is described herein lies primarily in the complete study of all the missiles, the making of one or more missile maps, and the plotting on these maps of the probable trajectories of the most important missiles. The reader will recall how useful the missile map of fork-lift-truck fragments proved to be in the investigation of the igloo explosion.

This procedure is based upon the axiom that whatever was present at the source or in the neighborhood of the explosion is still present after the explosion, unless it has been changed by the explosion into a vapor. This applies to all solid and liquid bodies and includes metal, concrete, steel, wood, and human remains.

The big job in an investigation is to find these pieces and identify them.

Once a fragment has been identified, it is usually comparatively easy to determine where it was just prior to the explosion. The investigator knows where the fragment was found after the explosion. The path of the missile is thus determined and the necessary force or polygon of forces to project the fragment along the path assumed taken can be plotted. Also, a study of physical characteristics of the fragment as found is of value in determining the temperature to which it has been put, whether or not it struck other objects in its flight, and whether it carries with it any markings of contact with these other bodies.

To be sure, many of the fragments will be too small to be of much value. In a large explosion, a number of relatively large fragments will be found and these large fragments will probably tell the story of what happened. Such was the case of the parts of the fork lift truck in the igloo explosion. The number that may have to be carefully studied varies.

The procedure followed in the investigation of accidental explosions, as developed in the Ordnance Department, has as its objective the obtaining of all information, eyewitness or circumstantial, from every available source. The keynote of the investigation must be care and thoroughness. It is rare that a clue which solves the problem can be found quickly. Even when such an unusual thing occurs it is not safe to rely upon it until the case is complete because the interpretation of the evidence involves the weighing of the relationship of all clues. In short, all the screened evidence must either confirm the final hypothesis, or at the worst, parts of the evidence must neither confirm nor deny it. No reliable circumstantial evidence can be adverse.

In screening or sifting of the evidence, care must be taken that trustworthy evidence is not ruled out because it in some way appears adverse to the final conclusion of the investigator.

Occasions may arise when the destruction will be so complete that the procedure as outlined cannot be successfully consummated. The author has heard of such cases although he, personally, has never found one. Many cases which appear at first to be in this class eventually yield sufficient information from fragments to determine the cause.

If therefore the investigator can find a sufficient number of pertinent missiles, identify them, know the exact locations in which they were found or the way in which they penetrated the earth or other softer body and the way they lie upon it, he can learn from them practically the entire story of just what they have been through.

CIRCUMSTANTIAL EVIDENCE

The complete story of circumstantial evidence comprises:

The condition of the premises

1 The determination of the presence of any unexploded explosives or ammunition, their locations, and prompt and safe removal.
2 The location of any badly injured or wounded, first aid and prompt removal.
3 The identification and location of the dead.
4 Weather data, particularly direction and velocity of wind, temperature, and relative humidity at the time of the explosion.
5 Craters, if present:
   (*a*) Their size and location as found.
   (*b*) Determination of their true size.
   (*c*) Excavation of contents of earth immediately below and around the crater and screening and sifting for fragments.
   (*d*) A crater profile and contour map may be made where it is needed for further study.
6 Effect of the blast on near-by structures or equipment.
7 The exact condition of remaining equipment, if any.
8 Missiles:
   (*a*) Identification.
   (*b*) Location, type, material, size, and weight.
   (*c*) Missile map.
   (*d*) Condition of fragments.
   (*e*) Marks on missiles.
   (*f*) Marks made by missiles on structures, other objects, or other missiles during flight.
9 Special study of corpses or pieces of corpses.
10 Full information regarding the process.
11 Types of equipment, blueprints of building, or the like.
12 Reports of other similar incidents occurring in the operation of this process or near incidents.

EXAMINATION OF EYEWITNESSES

In addition to the study of the circumstantial evidence all survivors and eyewitnesses should be interrogated. Numerous excellent treatises on the art of interrogation are available. Men legally trained are particularly well-qualified for this work, but whether the investigator uses such methods or not, one great difference must be pointed out.

The primary objective of the legal type of interrogation is to fix blame. The type of investigation that produces the scientific data necessary to become the foundation of engineering elimination of the hazards cannot be obtained if in the same interrogation an endeavor is made to fix blame. What is needed is the active co-operation of all who have had any experience in connection with the material or equipment involved in the explosion. This co-operation cannot be obtained if the witness does not actively assist the investigator and he will not do so if he fears that what he tells will in some way be used against him later.

Eyewitnesses are of particular value in establishing the sequence of events provided that these events do not occur too close together in either space or time. If less than five seconds intervene between two sharply defined events, or if they occur less than 100 ft apart, or if the lines of vision diverge by more than 20 deg, eyewitness testimony will be found generally unreliable when the witnesses are ordinary persons who have not been trained specifically in observation.

Time intervals are more easily established from oral testimony if the witness has performed some physical act between two events. If he then be timed by a stop watch when performing the same act, a good approximation of the time interval can be obtained even though he is not under the stress of the explosion itself.

For example, one witness heard two explosions. Immediately after the first explosion he arose from his chair, rushed to the floor above to seize his sleeping child, and returned with it to the comparative safety of the first room. The stop watch showed that he took seven seconds to perform this act

the day after the explosion. A seismograph record was taken of this explosion and showed an interval of $7\frac{1}{2}$ seconds.

PROCEDURE FOLLOWED BY INVESTIGATOR

It is highly important that the investigator reach the scene of the explosion as promptly as possible after it has occurred. He should be notified immediately after the explosion and must have available quick means of transportation to the scene, preferably airplane or automobile.

It is also important to make sure that no missile is disturbed until the investigator has seen it, a precaution, it will be remembered, that was taken in the case of the igloo explosion. Rescuers and firemen should be trained to disturb nothing if it is not necessary to do so in the fulfillment of their mission of safeguarding wounded and putting out fire. Where facilities permit, stakes or other identifying markers should be placed where wounded or dead are found.

Although some investigations require additional equipment, the following should be in every investigator's "blow bag:"

(*a*) 50-ft tape.

(*b*) Two wooden 6-ft collapsible rules plainly marked, preferably black markings on white. Because large figures can be easily read when photographs are taken, it is suggested that both the tape and rule be graduated in feet and tenths of feet rather than inches.

(*c*) One Brunton or similar hand compass equipped not only for horizontal direction finding but also for quick altitude estimations.

(*d*) One cross-section notebook, $8\frac{1}{2} \times 11$ in. sheets, preferably but not necessarily $\frac{1}{8}$-in. cross sections. Blue or green lines are preferred.

(*e*) One pocket notebook about $3\frac{1}{2} \times 6$ in.

(*f*) One $2\frac{1}{4} \times 3\frac{1}{4}$-in. camera with good lenses. A Speedgraphic is an excellent camera for this purpose. The investigator should know his camera thoroughly, the focal distance of its lenses, and other characteristics, so that he may be able to bring into his photographs definite figures of length.

(*g*) Flashlight equipment.

(*h*) Necessary pencils, preferably colored as well as black.

(*i*) Linen tags with long strings—3 × 6 in. with strings 24 in. long are excellent.

(*j*) One lapboard for field sketching.

(*k*) Occasionally on an extensive investigation the missiles will be so far spread that it is best to plot them by surveying. In this case a transit with stadia lines and necessary rods should be obtained.

The investigator should preferably be accompanied by one or two trained assistants because there is so much to do so quickly after his arrival. One of the assistants should immediately obtain a list of witnesses or possible witnesses and proceed with their examination. The other assistant should obtain maps of the location, plans and elevations of the building and equipment involved in the explosion, and also arrange for the use of a small office as near the site of the explosion as possible. This office should preferably be equipped with a drawing table and necessary drafting instruments. Arrangements should be also made for the use of a covered space as a museum to which the more important missiles can be brought for study.

The investigator himself should visit the site of the explosion immediately upon arrival and make mental notes of his plans of procedure. At this time he should decide which missiles should be carried away immediately because rain or moist air may cause rust or other discoloration of fresh breaks. He should also arrange for guarding the site so that no missiles are disturbed and simultaneously make sure for himself that no important-looking missile has been moved from its original location. In cases where removal was necessary in order to rescue a wounded person or to put out a fire, the investigator should determine just what movement was made and where the fragment originally lay. After this visit the investigator is ready to outline the detailed work of himself and his assistants. This work should be planned thoroughly. Depending upon the magnitude of the explosion, this work may require from one-half day to two or three weeks.

In cases where the investigator has no assistants of his own party, he will have to perform the functions of his assistants. This may sound like a big job, but the author has made investigations all alone with very little assistance from local or plant people and has not found the task too arduous. In order to do a good job promptly, however, the investigator needs assistants and these assistants in turn will have to call upon local aid. Local aid is an advantage in many ways, particularly in the identification of pieces. Plant millwrights, pipe fitters, operating engineers will be found to have an intimate knowledge of just how the equipment was put together, and what is of greatest value, those little differences in similar pieces of equipment which identify them. These identifying differences are frequently the arrangement of piping, or the use of different shims or "Dutchmen," or a different gear ratio or different widths of flanges or a different type of gasket. Local mechanical-department employees are generally the clearest thinkers when it comes to possibilities of behavior of the equipment.

Although the investigator must be prepared to take his own pictures, it is a great advantage to have a local photographer to relieve him of this burden. Photography is time-consuming and the investigator generally is not able to have negatives processed promptly.

Each photograph should be numbered and on a map or sketch the position of the camera and its direction of vision should be indicated. A pocket compass will suffice for direction and location may be plotted by pacing from some object shown on the map. This is necessary primarily to reduce the measurement distortions of a camera lens. Sometimes it is important to identify piping, and if several sizes of piping are involved, identification may be incorrect unless distances are known.

When pieces of equipment are being photographed, it will be well to open the 6-ft rule in the form of a square and lay that beside the object being photographed. A scale in feet and fractions of a foot shows up much better in a photograph than does a scale showing feet and inches and therefore the former should be used. See Fig. 9.

Where craters are found a most careful study should be made of them, of their dimensions, both apparent and true, and particularly of their contents. They should be measured accurately as they first appear and then, as they are excavated, a true crater conformation should be determined and plotted. The size of crater gives a clue to the amount of explosives involved, and the fragments found within the crater, by their penetration and missile flight, are of great importance because they were so close to the actual explosion. The study of craters is in itself a specialty, the detailing of which space does not permit.

SOMETHING ABOUT EXPLOSIVES

There are many excellent books of reference on explosives, their types and behavior, and much study has been made of the specific characteristics of different kinds. An investigator who desires to be skilled in the art certainly should avail himself of at least one or two of these reference books and should become thoroughly familiar with these characteristics. Repetition of this type of information is not justified here and therefore will not be described in any detail. It is necessary, however, to understand something about the initiating force that sends the missiles on their way and the paths missiles are likely to take.

When the investigator can get from his study a sufficiently vivid picture of what happened so that in his mind he can cause the missiles to replace themselves in their original positions, somewhat after the fashion of a motion picture of an explosion run backward, his hypothesis can be taken without question as being a true explanation of the explosion. In order to obtain this vision, it is necessary for the investigator to bear in mind the following few facts about the action of explosives.

As accidental explosions usually occur when the explosives are in some form of container, the behavior of the fragments of the container should be understood.

There is a definite relationship between the initial velocity of a fragment and the ratio between the area of charge and the area of the casing. This casing area is the cross-sectional area of all the solid material that has a surface in contact with the explosive, and the density of casing is the average density of the material of which it is made. A convenient chart, not reproduced here, gives velocities of fragments whose flights originated in the region where the cross section was taken. Different parts of the explosive system having different cross-sectional forms will produce fragments having different velocities.

The motion of the fragment is very nearly at right angles to the surface of the explosive, but it has a small component in the direction of propagation of detonation. This causes the fragment to leave its original position at right angles to the explosive when viewed in a plane at right angles to the line of progress of the propagation of the detonation. When viewed in a plane parallel to the axis of the direction of propagation of the detonation, the fragment leaves at an angle varying with the velocity of the propagation of the detonation but apparently never more than 15 deg from normal.

The velocities of fragments weighing more than a few ounces do not change appreciably in a free flight of 100 ft or so. An interesting fact is that the velocities are sufficiently high so that frequently the fragment will penetrate heavy reinforced-concrete walls without appreciable diversion, and furthermore it will penetrate and cut steel of an appreciable mass. Such a penetration was found in the telltale fork-lift-truck parts noted in the igloo explosion. Whether the structure is weakened by the blast prior to the advent of the fragment is very doubtful because of the velocities involved, although for a short distance the blast wave sometimes travels at from two to ten times the velocity of the fragment.

In a general-purpose bomb loaded with TNT the initial fragment flight is about 8000 ft per sec. If the fragment weighs 1 lb, the kinetic energy in it amounts to one half MV^2, or 1,000,000 ft-lb per pound of weight. If the fragment is of cast iron or steel, one pound would represent only four cubic inches of material which would have this tremendous kinetic energy of 1,000,000 ft-lb. Any reasonable ratio of length to cross section would give a surface so small that this missile, traveling with that amount of energy, would penetrate any light-constructed wall or floor without changing its direction of flight. Furthermore, in its flight through the air this missile would become very hot and in that way much of its energy dissipated.

In addition to the fragment velocity curve, the investigator should have some knowledge of the detonation rates of the types of military explosives he is likely to meet. Table 1 gives a few such rates.

TABLE 1 DETONATION RATES OF EXPLOSIVE MATERIALS

Material	Detonation rate, fps	Material	Detonation rate, fps
Nitroglycerin	25,500	Explosive D	21,200
RDX	24,500	TNT	20,400
PETN	23,800	50/50 amatol	16,800
Composition B	23,400	Lead azide	11,500
50/50 pentolite	22,500	Mercury fulminate	9,660
Tetryl	22,500	Ammonium nitrate	3,600 to 7,500
Picric acid	22,100	Cornstarch	25

MISSILE MAPS

The complete study of missiles involves their identification, a study of them where they are found, the making of a missile list and missile and missile-trajectory maps, the removal of the missiles that are apparantly important to the "museum" for further detail study of configuration, marks, and the like.

The missile map, of which an example was shown in the case of the igloo explosion, must be accurately made on a sufficiently large scale to insure the accuracy of projected lines. Such a map normally would become large and cumbersome and therefore the making of a few preliminary maps to a greatly reduced scale will be found advantageous. From these reduced-scale maps fragments or missiles deemed important may be selected and placed by the investigator upon the large maps for the complete study. The missile map shown in Fig. 6, on which only a few missiles have been plotted, is an excellent example.

The first missile-flight maps to be drawn should contain only the horizontal projection of the missile trajectory. In other words, it should be a plan view with the missile flight shown by a straight line. Where the missile has been diverted, the line may be broken, but it should be remembered that the horizontal projection of the flight of any large fragment is a straight line for much of the first part of its course.

Sometimes a vertical projection of the missile flight is also necessary. This of course only approximates a straight line, but at usual velocities for the first 50 or 100 feet from the source of the explosion a straight line is quite accurate and the true divergence from a straight line is impossible to detect.

On small-scale preliminary missile maps, therefore, the horizontal projections of all related missiles should be plotted and an endeavor made to connect up all parts of the same piece of equipment. In doing this the following facts should be borne in mind:

(*a*) If the explosion occurred within a vessel, the fragments should be found spread out in all directions and the pattern outline should roughly be a circle.

(*b*) If the explosion has occurred outside of and on one side of the vessel, then the fragments of that vessel should be found within two lines that converge so as to form a V with the point of the V, or intersection of the lines, at the place that the vessel stood at the time of the explosion.

If the V converges to indicate a position that was not the original position of the vessel, then two successive motions are indicated, one of translation from its original position to the place that it was broken into fragments, and another which was that of the resulting fragments.

If the center of fragments indicates a position which is not the original location of the vessel at the time of the explosion but some distance removed therefrom and if the fragments show a roughly circular pattern, then the vessel was thrown by an explosion occurring outside of it into a new location where a secondary explosion within itself occurred.

STUDY OF FRAGMENTS

Fragments that have been close to an explosion may show not only flame or flash burning but frequently also holes made by other missiles. Sometimes a single missile will make several holes which are quite similar in shape and in size. A projection through these holes will show not only the point of origin of the flight, but also its path. For these special studies a vertical as well as a horizontal projection is often necessary.

In the case of the igloo explosion such a hole was found in two of the telltale missiles and furnished evidence of the height of the forks at the time of the accident.

Marks on large fragments or missiles will indicate by the burning and the gouging effects the approximate direction of flight of other missiles, even if these missiles do not entirely penetrate the fragment.

Identification of fragments becomes much more complicated when two or more pieces of each type of equipment are present. In one example the important missiles from three almost identical complete sets of equipment were identified because of relatively slight peculiarities in one of the pieces of equipment.

In such a case, the most informative indication as to which fragment belongs to which piece of identical equipment is by means of a pattern of missiles. Although many preliminary missile maps may be required, it is rare that the pieces cannot be identified by the pattern of the various groups of missiles found and studying that pattern in relation to other known factors discovered in connection with the explosion.

Not only do pieces of equipment fall in a sector, the radii of which converge, but "families" of fragments will be found whose flight paths also converge. These families may be parts of a motor and its drive or similar subdivision of the equipment or auxiliary equipment. One of the tests for correctness of the original convergent V is to ascertain that families of other fragments also all show a V that indicates a spot approximately close to the other V centers thus found.

If more than one piece of identical equipment is involved in an explosion, the piece to which a fragment belongs can frequently be determined by the positions and locations of the two fragments found. If, for example, an explosion has occurred within two vessels and two adjacent fragments whose flight paths intersect at the center of one piece of equipment, but form an X if projected to the center of the other vessel because of crossing of the outside lines, it is easy to see that these fragments came from the first and not the second piece of equipment. Had they come from the second piece of equipment, the fragment found on the right side of the V would have been found on the left side. It is assumed of course that these fragments have previously been identified as having been part of the same equipment and adjacent to each other by mating.

Again a word of caution regarding the size of missile considered in this type of analysis. Very light missiles with large surfaces, such as sheet-metal covers, may be diverted by wind resistance from true missile trajectories. Heavier missiles, weighing a few pounds, are rarely, if ever, so diverted.

The reason of course it is so necessary to find the point of initiation of an explosion is that this once determined ordinarily eliminates a large number of possibilities for the cause of the initiation. It frequently limits the possible causes to one or two and very little confirming evidence is necessary to ascertain which of the one or two possibilities actually occurred.

Although the explosion may, for all practical purposes, be considered a single one, a study of fragments sometimes shows that it actually occurred in a number of steps a few hundredths or even a few thousandths of a second apart. This short time interval is sufficient to permit certain fragments to receive the blast of the first explosion and be carried away by it before the second blast occurs. This is of definite help in studying the sequence of explosions and in itself frequently provides a method of eliminating possible causes. If, for example, a possible cause would affect only vessel No. 2, then it could not have been the cause of the explosion if it can be proved that the explosion originated in vessel No. 1.

As soon as pertinent missiles are carried into the museum, which should be a large empty space under cover and preferably with a good floor, it should be possible to begin putting these pieces together. In many cases only one very small surface on each of two fragments indicates the position in which they were originally held together. The rest of the fragment may be deformed by heat or physical blow until nothing of its original outline is left. The chances of making a mistake in this jigsaw puzzle of reassembling the fragments is not great if the work is done promptly and carefully and without attempt to force together fragments which do not belong together. As more and more fragments are assembled the work goes on rapidly and may be continued further than necessary unless it is watched.

FIRES

One of the most important matters to be determined in order to shed light on the origin of an explosion is whether or not fire was present prior to the explosion. A normal explosion of high-explosive dust leaves few marks of fire. In fact, high-temperature markings are infrequently encountered except in the case of steel fragments within the zone of explosion which may show welding or fusing of the metal, particularly at sharp edges. The problem frequently arises, however, as to whether a fire started before or after the explosion. Where a manufacturing building is involved, this can frequently be determined by the actions of employees. Generally, when a fire occurs in an explosives manufacturing or loading plant the operators have time either to escape or to move toward the escape ways. The finding of a body at the bottom of an escape chute is almost certain evidence that a fire occurred prior to the explosion. The failure to find bodies at such exit points is almost certain evidence that no fire occurred prior to the explosion.

STUDY OF HUMAN REMAINS

One of the most informative kinds of missiles are human bodies, in whole or in part, when they can be found. These frequently act as a sponge which accumulates other small missiles at the site of the explosion. The cause of death, that is, whether by concussion,[3] by being thrown against a stationary object, or impact or penetration by missiles, also gives valuable information, particularly as to how close the particular person was to the origin of the accident at the moment of the explosion and as to the type of explosion. It will be recalled that in the case of the igloo explosion cited the investigators were able to discover where the driver of the ammunition van and the girl on the crew truck were at the time of the accident. If the victim's duties required him to be at the site at the moment of the explosion, then some scrutiny should be made of his operating duties to determine whether they could have been a cause of the explosion or a contributing factor.

Generally speaking, bodies involved in high-order explosions do not show the effects of burning, but the contrary is true for low-order explosions.

The heat from the rapid burning of large quantities of smokeless powder and similar nitrated substances is frequently intense enough to kill a person by burning him by radiation at a considerable distance. One of the freakish attributes of such a fatality is the fact that frequently the clothing acts as protection, particularly if it is flameproof. Although radiated heat can and often does set ordinary clothing afire, there have been cases in which persons in ordinary clothing have died of the effects of heat even though their clothing was not ignited.

The justification for the procedure described in this article is merely the fact that it has been successful in practical application. The subject has been approached not from the viewpoint of scientific curiosity nor to satisfy morbidity, but simply to ascertain the causes of explosions in order that they may not recur. In so doing many thousands of lives have been safeguarded and it is hoped that continuation of its application by others will result in the saving of still more thousands of lives.

[3] "Concussion" is used in the sense of "blast effect," not with the medical meaning.

A Review of Some
HEAT-PUMP INSTALLATIONS

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INTRODUCTION

THE idea of using a heat pump for changing the temperature of air in a given space was first suggested by Lord Kelvin in a paper presented at a meeting of the Glasgow Philosophical Society in December 1852 (1).[1] Later he gave a theoretical discussion of his heating and cooling machine (2). His proposed machine had to be modified considerably in changing over from heating to cooling and, consequently, was never built. However, refrigeration machines operating on the Kelvin air cycle came into common use.

The heat pump was first used to provide year-round air conditioning, but it is now being used for processing in industries which produce paper, artificial silk, salt, sugar, condensed milk, and concentrated fruit juices. In all, there are over 200 heat-pump systems in operation today.

DEFINITIONS AND TYPES

For air conditioning, a heat pump is merely a refrigeration system used both for heating and cooling. The source of heat may be the atmosphere, earth, river, lake, well water, or waste heat. The change over from heating to cooling may be accomplished by the use of a system of dampers (3) or by interchanging the functions of the two heat exchangers (4). When the heat pump is used for industrial purposes, other than air conditioning, the type of system used will depend upon the particular application (5, 6, 7, 8, 9).

THE COEFFICIENT OF PERFORMANCE

For the heat pump to be practical it must have a suitable heat source, and for it to be economical it must have a relatively high coefficient of performance (C O P). The C O P of a heat pump as a warming machine is defined as the ratio of the quantity of heat delivered to the amount of energy supplied. The advantage of heating with an electrically driven heat pump over direct electric heating is illustrated by the use of the following hydraulic analogy:

Suppose there is a reservoir or tank of water, Fig. 1, 60 ft above the surface of the earth and another tank or reservoir 12 ft below the surface (10). A third reservoir or utilization tank is required to hold water for domestic purposes. Let 1 lb of water flow from the upper tank directly into the utilization tank without passing through the water turbine. The supply tank lost 1 lb of water and 60 ft-lb of potential energy, while the utilization tank merely gained 1 lb of water.

Suppose this procedure is repeated under slightly different conditions by letting 1 lb of water flow from the supply tank through the water turbine that is connected to the centrifugal pump on into the utilization tank. If the entire hydraulic system is 100 per cent efficient, the 60 ft-lb of potential energy is all available as useful work to raise 5 lb of well water 12 ft;

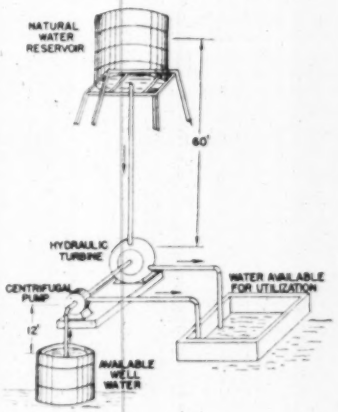


FIG. 1 HYDRAULIC ANALOGY TO EXPLAIN MEANING OF COEFFICIENT OF PERFORMANCE OF A HEAT PUMP

and 5 lb of water is added to the 1 lb which came from the supply tank, making a total of 6 lb in the utilization tank for domestic consumption. The ratio of the useful quantity of water delivered to the quantity of water supplied is 6 to 1 and the theoretical C O P of the hydraulic system is said to be 6.

If the over-all efficiency of the hydraulic system is 64 per cent, the actual C O P of the system is 4.20. An electrically driven heat pump with an actual C O P of 4.20 would supply 4.20 kwhr of heat for warming a given space for 1 kwhr of electric energy supplied. The 1 kwhr of high-grade electric energy which is supplied to the motor of the heat pump corresponds to the 1 lb of water supplied to the hydraulic turbine from the upper reservoir. The heat pump merely raises the temperature of 4.20 kwhr of low-grade energy from the heat source which is analogous to the 5 lb of water pumped from the lower tank in the hydraulic system.

If the hydraulic system could have been designed so that the level of the water in the lower tank was only 6 ft below the surface of the earth, other things being the same, the ideal hydraulic system could have pumped 10 lb of water into the utilization tank; the theoretical C O P would have been 11, and the actual C O P would have been 7.40. In like manner, the heat pump will have a higher C O P the smaller the temperature difference between the heat source and that of the space to be heated.

A house that is heated with a heat pump having a C O P of 4.20 will supply 4.20 times as much heat per dollar spent as if it were heated directly with electric-resistance heaters. The importance of having a heat pump with a high C O P is now quite apparent. To compete favorably with a house heated by gas or oil, the heat pump should have a C O P of about 3.5 in localities where electric energy is available at about 1 cent per kwhr.

DOMESTIC HEAT PUMPS

About three-quarters of a century after Lord Kelvin published his first paper on the possibilities of heating and cooling buildings with a refrigeration plant, Haldane performed some experiments with a heat pump in London (11, 12). Fig. 2 is a schematic diagram of the heat-pump system which he installed in his house in Scotland primarily for experimental purposes. The system was designed so that the heat source could be out-

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Power Division and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

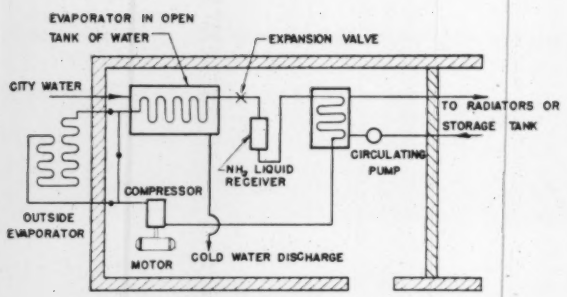


FIG. 2 SCHEMATIC DIAGRAM OF EXPERIMENTAL HEAT PUMP IN HALDANE'S HOUSE IN SCOTLAND

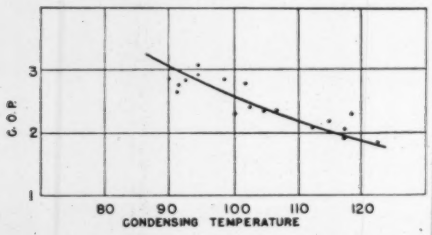


FIG. 3 TEST RESULTS ON EXPERIMENTAL HEAT-PUMP INSTALLATION IN HALDANE'S HOUSE, WITH EVAPORATOR TEMPERATURE OF 20 F

door air, city water, or both. Repeated measurements to determine the C O P were made over a prolonged period and his results are shown graphically in Fig. 3.

Tidmarsh installed a heat pump in his house in Tucson, Ariz., in 1930. This installation consisted of a 10-hp ammonia compressor, expansion valve, condenser, and evaporator. When the heat source was outdoor air, difficulty was encountered in heating the house. The system was changed so that either city water or well water could be used as the heat source. Tidmarsh concluded that his heat exchangers did not have sufficient surface area when the atmosphere was used as the source of heat. With a C O P of 5 and electric energy at 1 per cent per kwhr, he thought his heat pump would compare favorably to heating with gas- or oil-fired furnaces.

Wilkes and Marbury have discussed the performance of several domestic heat-pump installations in East Pittsburgh, Reading, and Philadelphia (13, 14, 15). The average C O P of a domestic heat-pump installation, using outdoor air as a source of heat, in an unoccupied bungalow in Reading, was 3.

In 1937 John Mangel installed a heat pump to provide year-round air conditioning in his residence at Riverside, Calif. The house was insulated with glass wool and had a volume of 20,000 cu ft. The heat gain was estimated at 32,000 Btu per hr and the heat loss at 54,000 Btu per hr (16). City water at 7 cents per 100 cu ft was used as the heat source and electric energy was available at 1 cent per kwhr. Accurate tests were made and the results are given in Tables 1, 2, and 3. The C O P was found to be 5.3 and 4.95, respectively, for outdoor dry-bulb temperatures of 48 F and 35 F.

In 1938 Col. C. E. Boggs, Boise, Idaho, installed a heat-pump system in his new house to provide panel-heating. The house has 1150 sq ft of floor space, a volume of 10,880 cu ft, and is insulated with 3 in. of rock wool. The total heat loss for the house was estimated to be 53,470 Btu per hr and was checked very closely by the measured output of the heat pump. The condenser consists of approximately 6000 ft of $^3/_{16}$-in. copper tubing embedded in the interior of the outside walls and a small part of the ceiling. The average of three tests gave a C O P of 3.33

TABLE 1 OPERATING COSTS FOR DOMESTIC HEAT PUMP IN MANGEL'S RESIDENCE AT RIVERSIDE, CALIF.[a]

	Compressor and fan	Condenser water
April	$ 0.80	$ ...
May	0.95	...
June	1.10	0.85
July	2.25	1.40
August	3.40	2.35
September	1.95	1.25
October	0.75	...
November	2.85	2.20
December	4.95	3.57
January	5.67	3.90
February	6.00	4.20
March	4.80	3.10
Total	$35.47	$22.82

[a] Data supplied by John J. Mangel.

TABLE 2 TEST DATA ON THE DOMESTIC HEAT PUMP IN MANGEL'S RESIDENCE[a]

Test made on a 48-deg-F day	
Outside dry-bulb temperature, deg F	48
Inside dry-bulb temperature, deg F	74
Air circulated, cfm	1850
Air entering condenser coil, deg F	72
Air leaving condenser coil, deg F	93
Suction pressure, psig	44
Head pressure, psig	122
City-water temperature (heat source), deg F	65
City-water consumption, gph	180–200
Input to compressor motor, Btu per hr	7600
Output, Btu per hr	40200
C O P	5.3

[a] Data supplied by John J. Mangel.

TABLE 3 TEST DATA ON THE DOMESTIC HEAT PUMP IN MANGEL'S RESIDENCE[a]

Test on a 35-deg-F day	
Outside dry-bulb temperature, deg F	35
Inside dry-bulb temperature, deg F	75
Air circulated, cfm	1800
Air entering condenser coil, deg F	72
Air leaving condenser coil, deg F	92.5
Suction pressure, psig	40.7
Head pressure, psig	126.2
City-water temperature (heat source), deg F	65
City-water consumption, gph	210
Input to compressor motor, Btu per hr	7850
Output of plant, Btu per hr	38900
C O P	4.95

[a] Data supplied by John J. Mangel.

for the installation (17). The heat source is 56 F well water. The operating cost of this heat-pump installation is about equal to 140,000 Btu per gal of fuel oil which retails at 10 cents per gal and is equivalent to electricity at 1.36 cents per kwhr. The actual annual load factor is 15 per cent (18).

The first "package heat-pump unit" was built by the Thermador Electrical Manufacturing Company of Los Angeles in 1938. One of these heat-pump units was installed in a seven-room house owned by Dr. Philip Vogel at Mojave, Calif., where the temperature varies from 10 F in the winter to 118 F in the summer (19). Fig. 4 shows this domestic heat-pump system which consists of a 3-hp compressor and a 5-kw auxiliary electric heater built directly in the bonnet of the unit. The atmosphere is the heat source, and laboratory tests on this unit showed that the C O P varies from 1.84 to 3.29, respectively, for outdoor temperatures of 25 F and 70 F.

In 1940 J. A. Hill installed a heat pump in his residence at San Francisco, which uses 61 F well water as the heat source. This plant was made from a discarded SU-90 Mobilaire store

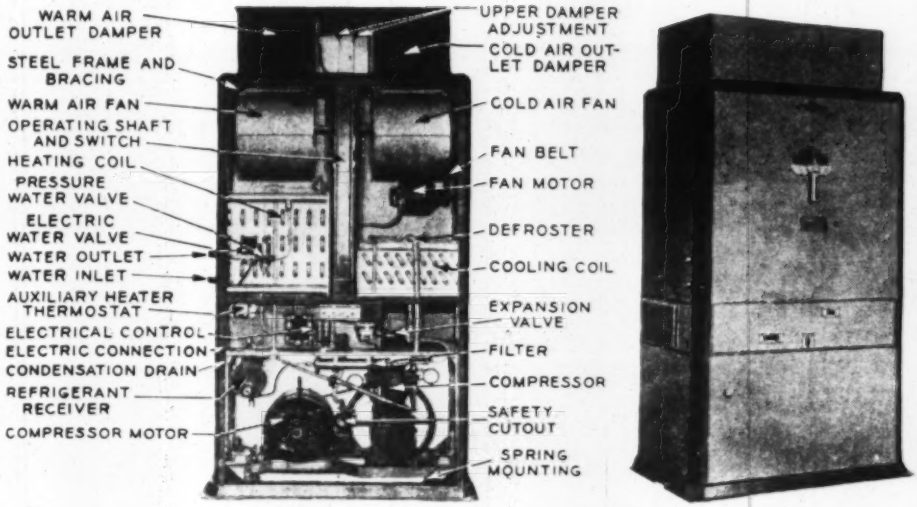


FIG. 4 THE THERMADOR THERMACOOLER

(Illustration supplied by C. A. Rowley, Thermador Electrical Manufacturing Company.)

cooler and consists of a $2^1/_2$-hp compressor, a condenser, and an evaporator. It has a heating output of 47,000 Btu per hr with a C O P of 4.2.

The Muncie Gear Works installed a heat-pump system in the four-room house of Robert Peckinpaugh at Muncie, Ind., in 1944. The heat pump consists of a 3-hp Servel compressor, condenser, cooler, fan, and thermostatic controls. Table 4 gives test data on this heat pump when city water was used as the heat source.

TABLE 4 TEST DATA TAKEN ON THE HEAT PUMP INSTALLED IN PECKINPAUGH'S RESIDENCE[a]

City-water inlet temperature, deg F	43
Water temperature at exit, deg F	36
Water consumption, gph	420
Total heat from water, Btu per hr	24402
3-hp compressor motor, w	3085
Total heat available from motor, Btu per hr	10526
Total heat delivered to air, Btu per hr	34928
C O P of plant	3.32

[a] Data supplied by M. M. Smith, vice-president, Muncie Gear Works.

Robert C. Webber installed a heat pump in his five-room house in Indianapolis in 1945. This installation consists of a 3-hp Servel compressor, condenser, evaporator, and automatic controls. During the heating cycle, the earth is the source of heat. The evaporator is a length of $^3/_4$-in. copper tubing installed outside the house about 4 ft below the surface of the earth. During the first tests, valves were arranged so that different coil lengths could be used as desired. Tests made on this heat-pump installation by the Indianapolis Power & Light Company showed a C O P of 3.61 and an average load factor of 28 per cent from October to May. During this test period, the inside dry-bulb temperature was maintained at 72 F to 74 F (20).

Table 5 is a summary of eight experimental domestic heat-pump installations. The average C O P for seven of these heat pumps is 3.58. The results of these tests indicate that heating with a heat pump will compare favorably to heating residences with oil or gas.

RAILWAY CARS

An experimental heat pump was installed in an MU passenger car of the Pennsylvania Railroad operating between Philadelphia and Paoli (21, 22). This heat-pump system provided air conditioning for the passengers from July, 1934, to February, 1935. Two heat-pump systems were installed, one 3-ton compressor at each end of the car. These units consisted of hermetically sealed compressors, fans, a condenser, evaporator coils, and reversing equipment. During the heating cycle the outside air was the heat source. The over-all C O P of the heat pump during the heating cycle was found from tests to be 2.54 when the outside-air temperature was 31 F.

TRUCKS

In 1945 a heat pump, known as the Trail-Aire Conditioner, was designed to supply year-round air conditioning in a Fruehauf refrigerator van (23). This package-unit heat-pump system is self-contained and consists of a 4-cylinder V-type air-cooled gasoline engine, compressor, condenser, evaporator, and automatic controls. Waste heat from the gasoline engine is utilized to increase the efficiency of the system during the heating cycle.

COMPARATIVE HEATING COSTS

Comparative heating costs are shown graphically in Fig. 5. In making the calculations, it was assumed that gas and oil

TABLE 5 SUMMARY OF EIGHT DOMESTIC HEAT-PUMP INSTALLATIONS

Owner and location	Approximate volume of house, cu ft	Compressor capacity, tons	Manufacturer of compressor	Heat source	COP
Haldane, Scotland	...	....	.....	Air, water	2.50
Mangel, Riverside, Calif.	20000	2	G.E.	City water	5.13[a]
Hill, San Francisco, Calif.	...	$2^1/_2$	Westinghouse	Well water	4.2
Vogel, Mojave, Calif.	...	3	BeDell	Air	...
Boggs, Boise, Idaho	10880	$3^3/_4$	Westinghouse	Well water	3.33
Peckinpaugh, Muncie, Ind.	5630	3	Servel	City water	3.32
Webber, Indianapolis, Ind.	6944	3	Servel	Earth	3.61
....., Reading, Pa.	...	1	.....	Air	3.00
				Average...	3.58

[a] Average of two tests.

TABLE 6 COMMERCIAL HEAT-PUMP AIR-CONDITIONING INSTALLATIONS IN AMERICA

Company and location	Date set in operation	Approximate volume, cu ft	Capacity tons	Manufacturer	Heating cycle: Heat source	Heating cycle: Outdoor dry bulb deg F	Heating cycle: COP[a]
Gay Engineering Co., Los Angeles	1937	126000	15	Westinghouse	Air	50	3.30
City of Los Angeles, N. Hollywood, Station E	1938	41500	15	Westinghouse	Air	36	3.12
City of Los Angeles, N. Hollywood	1940	40000	15	Carb'e	Air	57	2.53
City of Los Angeles, San Fernando	1938	23250	7½	Westinghouse	Air	49	3.11
So. Calif. Edison Co., Santa Ana	1940	116700	15	Carrier	Air	60	1.50
So. Calif. Edison Co., Whittier	1937	75350	10	Westinghouse	Air	63	7.35
So. Calif. Edison Co., Montebello	1938	50100	10	Frigidaire	Air	51	3.81
So. Calif. Edison Co., San Bernardino	1937	73800	10	Carrier	Air	46	2.04
Calif. Elec. Power Co., Riverside	1936	350000	75	Westinghouse	Well water	42	4.24
Westinghouse Elec. Co., Emeryville, Calif.	1939	90000	15	Westinghouse	Air		3.40
Ohio Power Co., Steubenville, Ohio	1937	170000	40	General Electric	Air		
Ohio Power Co., Coshocton, Ohio	1940	169000	25	Westinghouse	Well water		3.30
Ohio Power Co., Portsmouth, Ohio	1940	200000	50	General Electric	Air and city water		2.62
Ky. & W. Va. Power Co., Pikeville, Ky.	1936	120000	20	Frigidaire	Well water		3.20
Appalachian Elec. Power, Logan, W. Va.	1939	114000	30	Carrier	Well water		
Atlantic City Elec. Co., Salem, N. J.	1934	76800	20	General Electric	Well water		3.25
Atlantic City Elec. Co., Pittman, N. J.	1936	59000	15	York	Well water		
United Illuminating, New Haven, Conn.	1940	1570000	320	Westinghouse	Well water		2.90
Cine Novedates, Buenos Aires	1939		50		Well water		

[a] C O P calculated from test data.

Average C O P 3.31

were burned at an efficiency of 75 per cent and coal was burned at an efficiency of 65 per cent. With electricity at 1 cent per kwhr, the heating cost per million Btu is $2.90 with direct electric heating and $0.83 with a heat pump having a C O P of 3.5. To produce heat at $0.83 per million Btu, gas and oil should be available at 6.2 cents per therm and 8.2 cents per gal, respectively. On the other hand, to produce heat at $0.50 per million Btu, the heat pump should have a C O P of 6 with electricity at 1 cent per kwhr to compete favorably with coal at $8 per ton.

Heating with a domestic heat pump having a C O P of 3.5 and with electricity at 1 cent per kwhr, the heat pump compares favorably to heating with gas and oil. However, the efficiency of the heat pump must be greatly increased before it can compare favorably with a stoker-fired furnace.

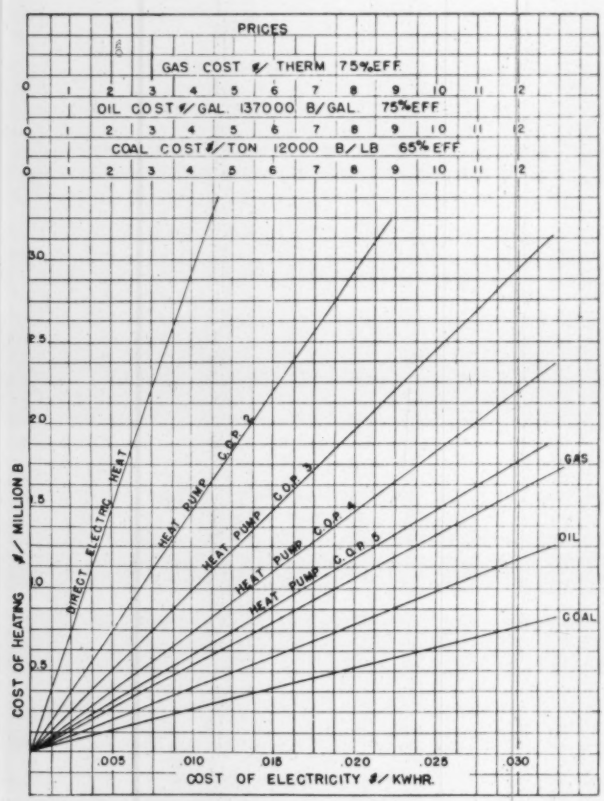


FIG. 5 COMPARATIVE HEATING COSTS

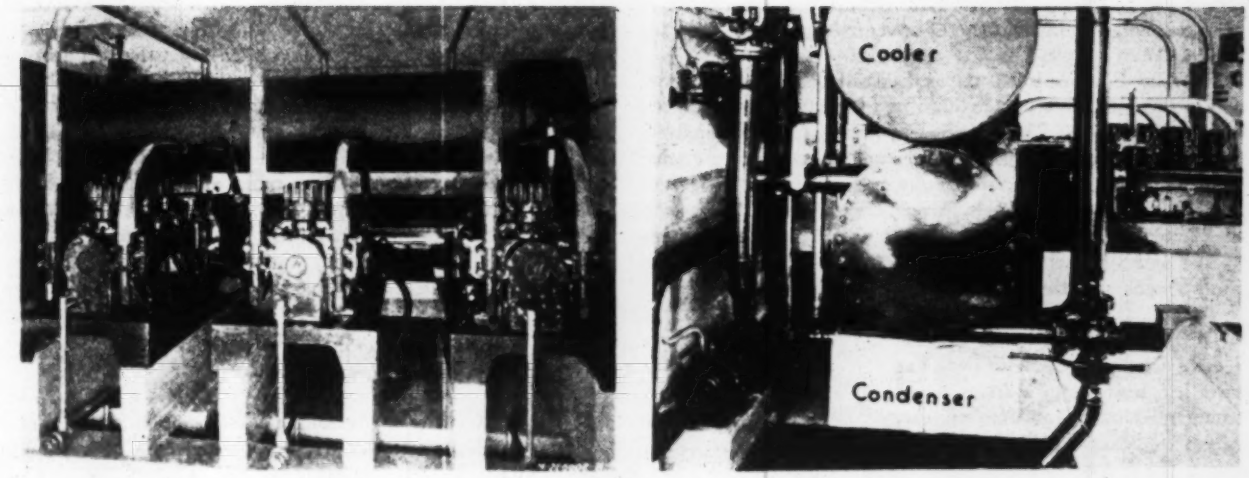
COMMERCIAL HEAT PUMPS

A 480-ton refrigeration plant was installed in the office building of the Southern California Edison Company at Los Angeles in 1931 as a part of the air-conditioning system (19, 24, 25, 26). It was arranged so that one of the four 120-ton compressors could be used as an experimental heat pump to warm the incoming air in the distribution system. This experimental heat pump was able to show a C O P of 2.8 under normal weather conditions at full load. Due to the particular design of the air-conditioning system it was not a good application of the heat pump and was discontinued in 1936 (19).

A summary of 19 commercial heat pumps is given in Table 6. Ten of these installations use air for the heat source, and the rest use water. In the California area where air is the source of heat, a system of dampers is used to change over from heating to cooling, except at the North Hollywood commercial office where solenoid valves are used to reverse the function of the two heat exchangers. The heat-pump system in Buenos Aires provides year-round air conditioning in "Cines Novedates," a 700-seat moving-picture theater (27).

Table 7 is a summary containing installation and operating data on four heat-pump installations at Whittier, San Bernardino, Montebello, and Santa Ana. The tests, made by California Institute of Technology students, were performed under rather adverse circumstances and were of short duration. The C O P of 7.35 for Whittier and 1.5 for Santa Ana are questionable; the former is probably too high and the latter too low. The test C O P of 2.04 at 46 F is also probably low, for the actual calculated over-all average annual C O P is about 4 for the heat pump at San Bernardino. Table 8 gives a summary of operating data on the foregoing heat-pump installations. The average annual load factor of the four heat pumps is 25.9 per cent and the average installation cost was $6580 (19).

From Table 6 it is seen that the City of Los Angeles has three heat-pump installations which provide year-round air conditioning in its commercial office buildings. The offices of the Gay Engineering Company are also air conditioned with a heat pump (28). The heat-pump installations at North Hollywood



Approximately, 4 tons of ice a day would be required every 24 hours to equal the capacity of these three Westinghouse Air Conditioning Compressors. In the upper background, the evaporator is shown with the condenser immediately below it. Well water at 65° is pumped into the system by an electric pump located beneath the grating in the foreground. The water circulating pump is shown at the left of the condenser. The compressors and control panel are at the right, in the rear.

FIG. 6 HEAT-PUMP INSTALLATION, CALIFORNIA ELECTRIC POWER COMPANY, RIVERSIDE, CALIF.
(Illustration supplied by Gay Engineering Company.)

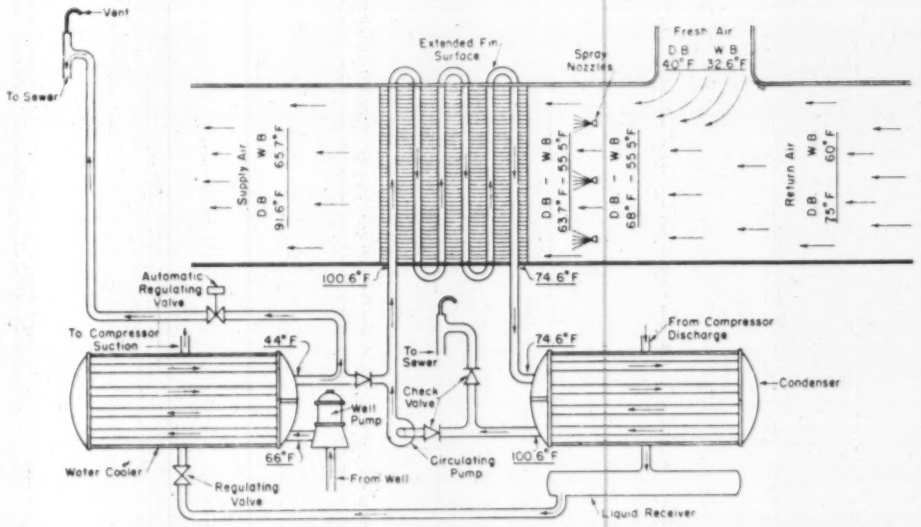


FIG. 7 FLOW DIAGRAM OF HEATING CYCLE, CALIFORNIA ELECTRIC POWER COMPANY

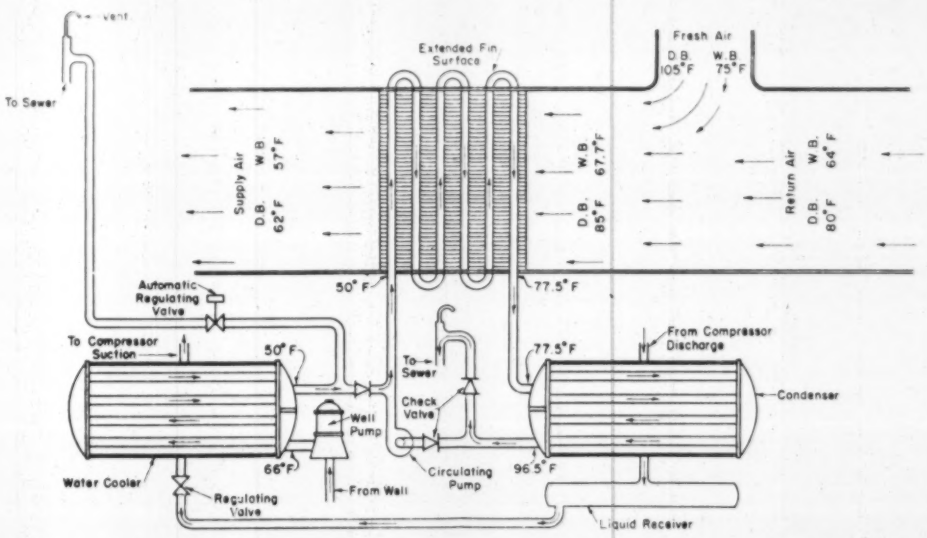


FIG. 8 FLOW DIAGRAM OF COOLING CYCLE, CALIFORNIA ELECTRIC POWER COMPANY

(Station E) and Emeryville are excellent illustrations of dampers being employed to change over from heating to cooling (3, 29, 30).

The Gay Engineering Company installed a heat-pump system in the commercial office building of the California Electric Power Company at Riverside. The system consists chiefly of three 25-hp Westinghouse compressors, a condenser, cooler, well pump, circulating pump, heat exchanger, and automatic controls. The refrigerant is Freon-12, and 68 F well water is the source of heat. Fig. 6 shows this heat-pump system. Figs. 7 and 8 are schematic flow diagrams for the heating and cooling cycles of this heat-pump installation.

The American Gas and Electric Service Company of New York has installed heat-pump systems in its commercial offices at Steubenville, Coshocton, and Portsmouth, Ohio; Pikeville, Ky.; Logan, West Va.; Salem and Pittman, N. J. (4, 31, 32, 33, 34). Data on these installations are given in Table 6.

A 320-ton heat pump was installed in the three-story administration building of the United Illuminating Company at New Haven, Conn., in 1940 (30, 35, 36, 37). The heat-pump system consists of eight 40-ton Westinghouse condensing units mounted on a single structural-steel base supported by Korfund adjustable spring mountings. All piping between the refrigeration equipment mounted on the base and the building piping system carries flexible connections to prevent transmission of noise and vibration. Each of the eight refrigerating units consists of a Westinghouse vertical 8-cylinder compressor with the driving motor mounted on its crankshaft and hermetically sealed in the compressor casting, 2-pass horizontal shell-and-tube condensers, and a Westinghouse vertical shell-and-coil water-chilling unit, and automatic controls. The source of heat is 57–58 F well water supplied by six 10-in. wells which are 28 ft deep. The average C O P for 4 years was found to be 2.9.

COMMERCIAL HEAT PUMPS IN EUROPE

Baumann has described a heat-pump installation in the Lucens Cheese Factory where a thermocompressor is used for the concentration of milk (6). Fig. 9 is a schematic diagram of a concentrating plant where a heat pump is used to heat a weak solution such as milk or any other suitable agricultural product. An electric motor drives a thermocompressor which pumps the low-pressure steam given up by the milk or weak solution in the boiler or heater, and forces it into the heating coil at a much higher pressure. The high-pressure steam in the heating coil gives up heat in condensing. The condensate, in turn, gives up further heat to the milk or weak solution in the heat exchanger before being discarded. The condensed milk or concentrated solution is taken out at the bottom of the boiler. In this system the low-pressure steam from the boiler is the source of heat for the heat pump and the function of the thermocompressor is to raise the temperature of the low-grade energy which is then used to boil the milk or weak solution. Since 1928 Brown Boveri & Company, Ltd., has installed

TABLE 7 SUMMARY DATA SHEET ON INSTALLATION AND OPERATION OF HEAT-PUMP AIR-CONDITIONING PLANTS IN SOUTHERN CALIFORNIA EDISON COMPANY, LTD., DISTRICT OFFICE BUILDINGS[a]

Item	Whittier	San Bernardino	Montebello	Santa Ana
Date put in service	March, 1937	June, 1937	June, 1938	Sept., 1940
Cubic feet conditioned area in building	75300	73800	50100	116700
Number of floors in building	One	One + mezz.	One	Two
Calculated heating load; if direct electric heat, kw	47	79	72	88
Tons of refrigeration installed; heat pump	10	10	10	15
Number of compressors	1	1	1	2
Horsepower of compressor motor(s)	10	10	10	15
Horsepower of fans (2)	5	4	4	10
Rated capacity, outside air, cfm	6240	....	4180	18000
Rated capacity, conditioned air, cfm	4740	4090	4180	12000
Main source of heat	Air	Air	Air	Air
Supplemental source of heat	None	Water	Water	Water
How accomplished	...	Spray heads	Fin coil	Evap. cond.
Frost prevention on evaporator coil	None	Preheat spray	Preheated coil	Evap. cond.
Provision for defrosting	None	None	None	Evap. cond.
California Institute of Technology; test of C O P	7.35	2.04	3.81	1.5
Made at OD temperature of (deg F)	63	46	51	71

[a] Data supplied by H. H. Douglas, Industrial Power Engineer, Southern California Edison Co.

TABLE 8 SUMMARY DATA SHEET ON INSTALLATION AND OPERATION OF HEAT-PUMP AIR-CONDITIONING PLANTS IN SOUTHERN CALIFORNIA EDISON COMPANY LTD., DISTRICT OFFICE BUILDINGS

Item	Whittier	San Bernardino	Montebello	Santa Ana
Average annual operating kwhr for year-round air conditioning	24096	38900	25667	52326
Maximum demand, observed as of record, kw	11.5	13.85	14.4	21.9
Average annual load factor, year-round air conditioning, per cent	24	32.05	20.2	27.4
Average annual kwhr chargeable to heating	7996	11440	8556	21800
Average annual load factor, heating only, per cent	7.94	9.42	6.75	11.35
Average annual kwhr chargeable to cooling	16100	27460	17111	30526
Average annual load factor, cooling only, per cent	15.88	22.63	13.5	15.95
Average monthly kwhr for 3 cold months (Dec., Jan., Feb.)	1648	2363	1717	4531
Average monthly kwhr for 3 hot months (July, Aug., Sept.)	2742	4546	3314	5071
Average annual kwhr per cu ft, heating	0.106	0.155	0.171	0.187
Average annual kwhr per cu ft, cooling	0.212	0.372	0.342	0.262
Average annual kwhr per cu ft, year-round air conditioning	0.318	0.527	0.513	0.449
Annual cost of power for operation year-round air conditioning, dollars	531	672	530	901
Annual cost of power for operation, per cu ft, (cents)	0.71	0.91	1.06	0.77
Approximate installation cost, dollars	5500	5400	6500	8900
Installation cost per cu ft of conditioned space, cents	22.9	14.6	25.3	17.0

over 30 heat pumps for the following purposes: Condensing milk and fruit juices, salt-evaporating plants, distillation, processing, concentration of yeast extracts, chemical industry, and medicinal purposes.

Table 9 is a summary of some of the Brown Boveri installations where heat pumps are used to heat water and to provide for air conditioning. The heat pump installed in the Landquart Paper Mills uses air as the refrigerant and therefore requires both a compressor and an expansion machine (5, 7, 38). These two machines are combined as a unit in the Brown Boveri cellular rotor. Moist warm air coming from a paper machine serves as the source of heat and is also utilized in waste-heat recuperators for heating the fresh air for drying the felts, before it traverses the heat exchangers of the heat pump. Approximately 180 tons of coal are saved annually by this heat pump without taking into account the preheating in the waste-heat recuperators. This plant has a C O P of 2.78.

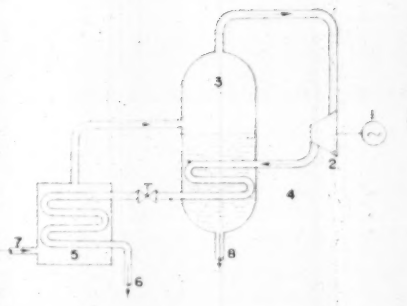


FIG. 9 CONCENTRATING PLANT WITH A HEAT PUMP

The centralized heating and power plant of the Swiss Federal Institute of Technology has installed three heat-pump units to supplement the conventional steam power plant. This subterranean heat-pump station consists of two Brown Boveri thermoblocs and a reciprocating compressor. River Limmat is the source of heat. In all, this centralized heating and power plant serves 142 public and private buildings.

The first heat-pump system in Switzerland, used for space heating and cooling, was installed by Escher Wyss (8, 39, 40, 41). This company installed a heat-pump system in the Zurich Municipal Public Bath which consisted of two separate elements; one unit was used for room heating and the other heated the swimming pool and supply water. This heat-pump system functions in the middle of the city without any chimney stack, coal bunkers, coal transport, smoke, soot, or noise. The Lausanne Artificial Ice Rink, equipped with a plant manufactured by Escher Wyss, serves simultaneously as a heat-pump heating system for the entire water supply of the city. Escher Wyss builds heat pumps for evaporation in which approximately 1000 tons of water are evaporated per hr per 50,000 kw energy input (9).

COMMERCIAL HEAT PUMP IN ENGLAND

John A. Sumner, city electrical engineer, designed and constructed a 23-ton heat-pump system which was installed in the office building of the Norwich Corporation electricity department. The heat source is 46 F water from the Wensum river which flows alongside the building. The building was erected in 1940 and it has a volume of 500,000 cu ft (42). Recent tests on this heat-pump installation show a C O P of 3.2, in spite of the fact that a 20-year-old ammonia compressor, with sulphur dioxide as the refrigerant is being used. Mr. Sumner has been authorized to design a heat-pump system for the Norwich City Hall which is to have a capacity of 20 therms per hr.

RECENT INSTALLATIONS

In 1946, Drayer-Hanson of Los Angeles manufactured and installed approximately 150 self-contained package-unit heat pumps which use the atmosphere as the heat source. This heat pump system, known as "Airtopia," gives complete comfort regardless of seasonal variations of heat or cold, dryness or humidity, without personal attention or adjustment. Airtopia installations vary in size from domestic to semicommercial, 3, 5, $7\frac{1}{2}$, and 10 hp, and are now operating in the states of California, Arizona, Nevada, Texas, Louisiana, Alabama, Georgia, Florida, and Oklahoma.

TABLE 9 BROWN BOVERI HEAT-PUMP INSTALLATIONS[a]

Plant	Date put in operation	Power input, kw	Refrigeration output, B per hr	Evaporation temp, deg F	Refrigerant	Heat source	Application
Landquart Paper Mills, Landquart, Switzerland	1941	50	460000	....	Air	Warm air from paper machine	Air heat pump
Steckborn Artificial Silk Works, Steckborn, Switzerland	1941	510	5560000	39	CCl_2H_2	Lake Constance	Heat pumps for heating water to about 160 F
Steckborn Artificial Silk Works, Steckborn, Switzerland	1941	510	5560000	39	CH_2Cl_2	Lake Constance	Heat pumps for heating water to about 160 F
Complementary heat-pump station of district heating plant of Swiss Fed. Inst. of Tech., Zurich, Switzerland	1942	585	6000000	28.4	CCl_2F	River Limmat	Heat pumps for heating water for district heating to about 160 F
Complementary heat-pump station of district heating plant of Swiss Fed. Inst. of Tech., Zurich, Switzerland	1942	585	6000000	28.4	CCl_2F	River Limmat	Heat pumps for heating water for district heating to about 160 F
Brown Boveri & Co., Ltd., Baden, Switzerland	1943	440	6000000	28.4	CCl_3F	River Limmat	Heat pump for central heating plant for offices and workshops
Steckborn Artificial Silk Works, Steckborn, Switzerland	1943	79	1600000	130	H_2O	Hot water from above heat pumps	Supplementary heat pump
Schlieren Dye Works, Schlieren, Switzerland	1945	170	2200000	44	CCl_3F	54 F ground water	Heat pump for heating water to maximum 140 F
Plant in Switzerland	1946	120	1685000	23	CCl_3F	Ground water	Combined heating and cooling for air conditioning

[a] Data supplied by Paul R. Sidler, president, Brown Boveri Corporation.

The Muncie Gear Works manufactures a domestic heat-pump system known as the "Marvair." This package unit uses well water as the source of heat without pumping any water from the wells. Five of these domestic heat pumps were installed in Chattanooga in 1946, where operating data are being taken.

COMMERCIAL HEAT PUMPS ON ORDER

The Westinghouse Electric Corporation (Sturtevant Division) is designing two heat-pump installations. One of these will be a 225-ton plant for Bullock's Department Store, Palm Springs, Calif. Well water will be the source of heat during the heating cycle and well water will be used for condensing purposes during the cooling cycle. The other heat pump is being designed for Western Air and Refrigeration, Inc., an air-conditioning contractor for the Westinghouse Electric Corporation.

THE AIR HEAT PUMP

Heat pumps using air as the heat source will probably have wide acceptance in California and the southern states since the heating and cooling loads will be approximately equal. This will be true particularly for semicommercial installations in restaurants, stores, and hotels, where cooling the air is required for competitive reasons. The domestic heat pump will be favorably received by those who can afford year-round air conditioning, since initial installations cost need not exceed that for plants using conventional heating and cooling equipment.

According to Wilkes and Marbury, the air heat pump will not have wide application in cities such as Philadelphia, Pittsburgh, Cleveland, and Chicago, owing to the formation of frost on the evaporator coils when the outdoor temperatures range from about 26 F to 38 F. Also, the capacity of the heat pump for heating greatly exceeds that for cooling. If the plant is designed, without a storage tank, to provide sufficient heat for the coldest weather, it will be too large for the summer requirement.

The straight line shown in Fig. 10 represents the heat loss for a well-insulated six-room house where the winter design temperature is —10 F. The heat-pump output for compressors of different capacities has been plotted against outdoor temperature. The values of the C O P of the air heat pump have also been plotted against the outdoor temperature. From this graph it is seen that the air heat pump has the lowest C O P when the building heat loss is the greatest. A graph is also shown for the C O P of the earth heat pump which is in operation in Webber's house in Indianapolis. This graph shows that the C O P is practically constant during the heating season for the earth heat pump and also for a heat-pump system where well water is the heat source.

For the cities mentioned there are comparatively few days during the heating season when the outdoor temperature is, say, below 1 5F. A 5-kw heat-pump system would be nearly adequate with some supplementary heating. A heat-pump system, consisting of a 3-kw air heat pump and a 2-kw earth heat pump, would meet the heating and cooling requirements for most of the year. The 3-kw air heat pump would operate during both the heating and cooling seasons. It would run continuously during the heating cycle when the outdoor temperature was 32 F and intermittently for higher outdoor temperatures. The 2-kw earth heat pump could be used to supply hot water throughout the entire year.

The system could be designed so that some hot water from the storage tank could be used to preheat the outdoor air before it passes over the evaporating coils. This would prevent frosting of the evaporating coil during the heating cycle and at the same time raise the temperature of the heat source, which in return would permit the air heat pump to operate at a much higher efficiency. With this system the 3-hp unit would have

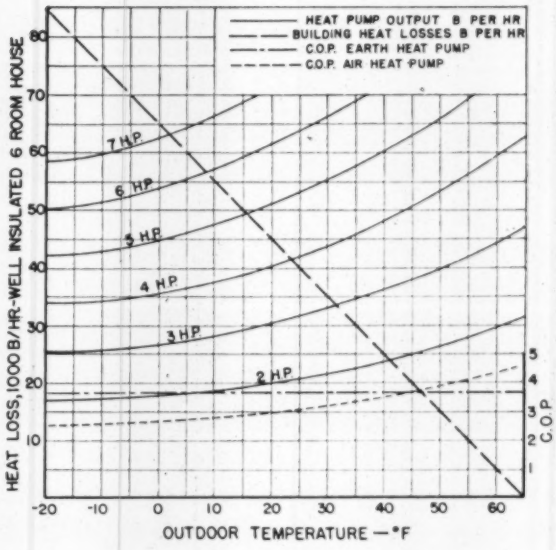


FIG. 10 AIR HEAT-PUMP OUTPUT
(On this chart read kw for hp.)

the correct capacity to take care of the cooling load. It has the disadvantage of a higher initial cost which would be partly compensated for by having a lower operating cost.

By referring to Table 6 it is seen that a 40-ton heat pump is adequate to heat a building of 170,000 cu ft at Steubenville, Ohio, where the winter climate is not much different from that at Chicago, for instance. Under similar conditions a 5-ton air heat pump (approximately 5 hp), should heat a building of 21,200 cu ft which is approximately the volume of a seven-room house. It would thus appear that the 5-hp heat pump chosen for the well-insulated six-room house described is probably adequate.

LOAD FACTOR

The following calculations were made to ascertain whether there is a preference, as to load factor, between the use of electricity and gas in year-round air conditioning. From the foregoing discussion it is clear that a 6-kw heat pump will be adequate to heat a well-insulated six-room house in Chicago. For these calculations the following assumptions were made:

Three tons refrigeration are needed for cooling
Building heat load is 75,000 Btu per hr at —10 F
Efficiency of a 3-ton Electrolux is 60 per cent and that of its burner is 8[illegible] per cent
500 hours per cooling season
2000 hours per heating season
Efficiency of a gas furnace is 75 per cent

(*a*) *Heating and Cooling With Gas.* The output of a 3-ton Electrolux is 36,000 Btu per hr. Then, $36{,}000 \div (0.60 \times 0.80) = 75{,}000$ Btu per hr. For a cooling season of 500 hr the gas consumption is 37,500,000 Btu or 375 therms for cooling. With a gas furnace of 75 per cent efficiency, 75,000 Btu per hr ÷ 0.75 = 100,000 Btu per hr or 1 therm per hr. For a heating season of 2000 hr, the gas consumption is equal to $2000 \times 1 = 2000$ therms. The total gas consumption for heating and cooling is 2375 therms. There are 8760 hr in a year, so the average yearly gas consumption is 2375 ÷ 8760 = 0.271 therms per hr.

Therefore

$$\text{Load factor} = \frac{\text{Average yearly rate}}{\text{Maximum rate}}$$

$$= \frac{0.271 \text{ therms per hr}}{1.0 \text{ therm per hr}}$$

$$= 0.271 \text{ or } 27.1 \text{ per cent for gas}$$

(*b*) *Heating and Cooling With an Electric Heat Pump.* For cooling, a 3-ton (or 3-kw) heat pump is adequate, and for 500 hr of cooling the electric energy supplied is 1500 kwhr. Heating with a 6-kw heat pump for 2000 hr, the electric energy required is 12,000 kwhr. The annual consumption is thus seen to be 13,500 kwhr and the average yearly rate of electric-energy consumption = 13,500 ÷ 8760 = 1.54 kw.

$$\text{Load factor} = \frac{\text{Average yearly rate of power consumption}}{\text{Maximum rate of power consumption}}$$

$$= \frac{1.54}{6}$$

$$= 0.257 \text{ or } 25.7 \text{ per cent}$$

Thus it can be seen that there is little or no choice, as to load factor, between the use of gas and electricity in year-round air conditioning. Boggs reported an average annual load factor of 15 per cent for his domestic heat pump. From Table 8 it can be seen that the average annual load factor for the four air heat pumps mentioned is 25.9 per cent, which is approximately equal to the value of the load factor just calculated.

CONCLUSION

Through experience it has been definitely proved since 1935 that the heat pump will work and that it is practical. The average C O P for the 22 domestic and commercial heat pumps listed in Tables 5 and 6 is 3.4. It seems probable that the efficiencies of both electric motors and refrigeration compressors in the low-capacity range could be improved through research. If so, the C O P of the heat pump would be increased. This, in return, would decrease the operating cost of the system.

The domestic heat-pump systems are in the experimental stage at the present time. If through research a domestic package heat-pump unit could be produced that is as reliable as the modern-household electric refrigerators there will be a demand for it in both the city and rural sections of our country. There will probably be a good market for heat pumps to produce hot water and year-round air conditioning on dairy farms that are remote from the coal fields.

The cost of heating with a heat pump having a C O P equal to 3.5 where electricity is available at 1 cent per kwhr is about equal to heating with either gas or oil. Where the climatic conditions are not too severe, the initial cost of a domestic heat pump is about equal to the conventional heating and cooling equipment used to provide year-round air conditioning.

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TUBE-STRAIGHTENING

Conventional Methods Employed by the Industries for Straightening Welded- and Seamless-Tube Stock

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THE straightening of tubes, either welded or seamless, is a stress-relieving process. This process necessitates bending or flexing the material beyond the elastic limit to a degree that results in a permanent neutralization of the stresses.

Before considering the various methods of straightening, it would be advantageous to examine briefly the reasons for this operation. Tubes are manufactured in numerous ways, and are recognized by the trade as follows:

"Hot-finished tube or pipe" is fabricated by the butt- or lap-welded method.

"Welded tubes" consist of cold-formed strip, welded by either the gas or the electric-arc process, or both.

"Seamless tubes" are pierced and rolled from solid billets or bars.

Keeping in mind the several methods used in the manufacture of tubes, it is apparent that the material is subjected to extremely high forces in the process of forming. These forces develop unbalanced stresses which tend to produce crooks, kinks, and bends in the finished product. Understanding the causes gives a key to what method should be employed to balance the stresses developed.

HAND- OR PRESS-STRAIGHTENING

The simplest means of straightening a tube, as illustrated in Fig. 1, is known as hand- or press-straightening. This consists

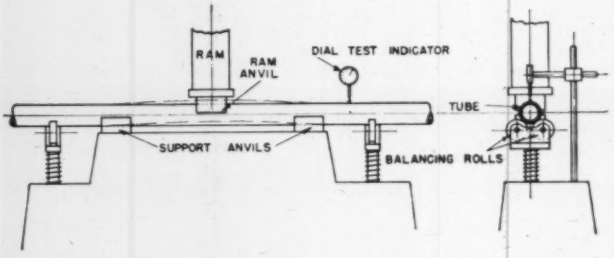

FIG. 1 PRESS-STRAIGHTENING METHOD

of a straightening press of conventional design. The press table is provided with anvils, so arranged that they can be placed at different distances from the center of the ram. The press ram is also provided with a suitable anvil and must have a variable stroke. The anvils used are grooved as shown to suit the tube diameter. In addition, spring-loaded balancing rolls are provided, as well as a dial indicator.

By placing the tube on the spring-loaded balancing rolls, slightly above the bottom straightening anvils, the tube can be rotated to determine the straightness by using the dial indicator. By rotating the tube so that the camber or bow is upward and under the ram, the ram is lowered, bringing pressure against

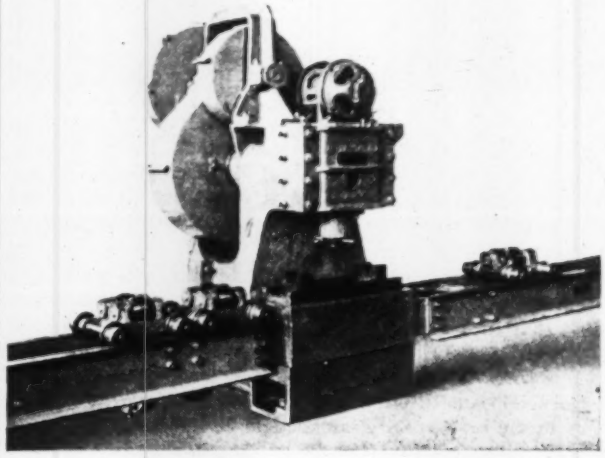

FIG. 2 PRESS FOR STRAIGHTENING TUBES

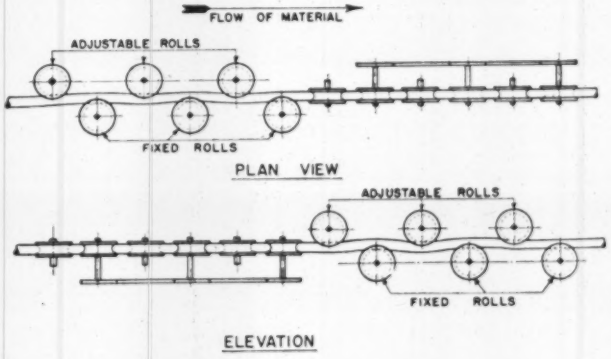

FIG. 3 ROLL-STRAIGHTENING PROCESS

the tube, depressing the springs supporting the balancing rolls and bending the tube between the two lower anvils an amount sufficient to reach beyond the elastic limit, and then releasing.

Again, the tube section is checked for straightness, and the operation is repeated over the entire length of the tube until a straight tube results. It may be mentioned that by this means the highest degree of straightness can be obtained. This method is an old one and familiar to everyone. It is generally used where precision straightness is required.

Although straightening by method 1 is practical, it is also slow and costly. Fig. 2 shows the type of straightening machine involved.

ROLL-STRAIGHTENING

Speedier methods have been devised. For example, Fig. 3, known as roll-straightening, is a rapid operation. This is a

Contributed by the Metals Engineering Division and presented at the Spring Meeting, Tulsa, Okla., March 2–5, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

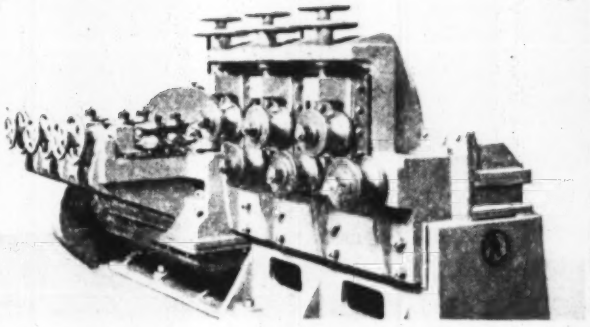

FIG. 4 ROLL-STRAIGHTENING MACHINE

machine having multiple-grooved rolls placed in both the vertical and the horizontal plane. These rolls are mounted on the machine in staggered formation as shown. The fixed, or permanently mounted rolls are power-driven, whereas the adjustable rolls are idlers. The adjustable rolls, located midway between the centers of the fixed rolls, provide means to flex the tube between the fixed rolls. The tube passing between these rolls is again bent past the elastic limit, thereby equalizing the stresses in the tubular member.

This operation is, in fact, quite simi'ar to press-straightening, except that by having the rolls mounted in two planes at right angles to one another, work may be performed on the tube in multiples from each plane. This is a commendable and speedy straightening operation when precision is not a factor. It can be realized that where extremely short bends in the tube are encountered, the tube, due to this defect, will have a tendency to rotate in the semicircular groove and follow the course of least resistance. No means are provided to prevent this, other than the frictional contact with the rolls.

So far we have considered round tubular sections only, but the industry is called upon to furnish tubular members of many other shapes; such as square, rectangular, oval, hexagonal, octagonal, and other cross sections. Whereas these special shape tubes can be straightened on the press straightener, Fig. 1, they can also be straightened successfully on the machine illustrated in Fig. 3, by designing suitable rolls. When straightening these special shapes, the tube is not apt to rotate in the grooved rolls, hence a better straightened product is realized. The roll-straightening method permits straightening speeds from 250 to 500 fpm.

Fig. 4 shows the roll straightener with roll contour for round tubes. These rolls can be substituted with contours for special shapes.

ANGULAR ROLL-STRAIGHTENING MACHINE

Fig. 5 illustrates a modern angular roll-straightening machine using five rolls. This machine embodies some of the latest features in straightening methods. The two larger rolls are power-driven, whereas the three smaller rolls are idlers. Located on the longitudinal center line between the rolls, there are provided specially formed guide shoes which can be adjusted both vertically and transversely to accommodate the tube diameter. When properly adjusted, these shoes assist the rolls in passing the tube between the rolls on the correct horizontal pass line. All rolls are shown machined to a concave contour with variations to correspond to their location. The angular mounting of these rolls, approximately 35 deg, can be adjusted to conform to the diameter of the tube. By means of this adjustment, the full length of the roll can engage the tube on the horizontal center line. In addition, the angular roll setting provides the longitudinal travel of the tube when rotating. By adjusting the roll angle it is possible to have the roll contour engage the tube at each end of the roll only and not in the center, thus providing the clearance to bend or flex the tube into the roll contour. The opposite result can be accomplished by reversing the angular setting of the roll, that is, engaging the tube in the center of the roll with ends of the roll disengaged to permit flexing by this means.

By this method of straightening, that is, bending or flexing the tube while it is rotating as well as moving longitudinally, every part of the tube is worked, causing the unbalanced stresses to equalize. In addition, the rolls are of a hardened material, with a ground and polished surface which will not mar or scratch the tube surface, but which, in most instances, will improve the outer tube surface. If during the straightening operation a light-grade oil is applied to the roll surface, a still better surface can be obtained, approaching a burnished effect.

There are other inherent characteristics in this type of machine which are commendable. For example, a skilled operator can increase or decrease the tube diameter at will, within limits, by roll-angle setting; he can also produce a straightened tube within very close diameter tolerance. Fig. 6 is a view of the angular five-roll straightener.

TWO-ROLL STRAIGHTENING MACHINE

Fig. 7 illustrates a two-roll straightening machine. The straightening principle of this machine is in reality the same as the five-roll machine, except that all of the work is performed

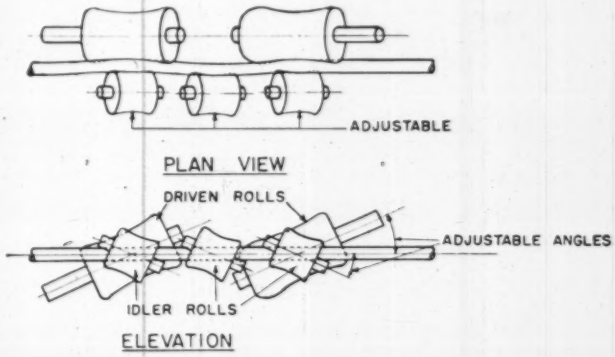

FIG. 5 ANGULAR ROLL-STRAIGHTENING USING FIVE ROLLS

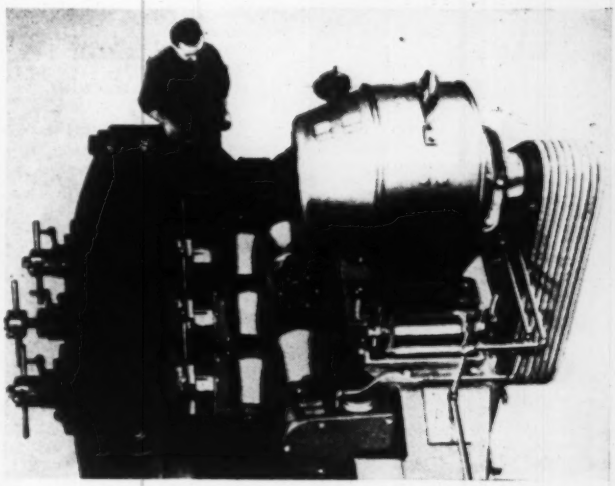

FIG. 6 ANGULAR FIVE-ROLL STRAIGHTENER

by two rolls. In this machine both rolls are driven; also, the conventional adjustable tube guide is provided to support the tube on the horizontal-plane line. This machine is furnished with one roll having a concave surface, and the other roll a convex contour. The angular position of these rolls is also adjustable, and the tube stock is firmly held while passing between them.

It has been the experience of the author that all machines have certain inherent characteristics which adapt them to certain specific applications. This machine will produce a fine straightening operation where the tube wall is of heavy gage, permitting heavy roll pressures which, in turn, will produce a fine finished surface. Another inherent advantage is that this machine will straighten tube stock close to either end, owing to the firm grip on the tube stock between the two rolls. In all cases, the skill of a trained operator is important. Fig. 8 shows this type of machine.

SIX-ROLL STRAIGHTENER

A six-roll straightening machine, which has been developed recently, is shown in Fig. 9. This machine differs from the former angular roll straighteners previously described in the application of the concave rolls. In this machine the rolls are placed in three pairs, each pair using one top and one bottom roll. This arrangement eliminates the use of guides for supporting the tube stock, because the bottom rolls guide the tube through the machine.

By referring to Fig. 10, it can be seen that both top and bottom entering and outlet rolls are driven, whereas the two center rolls are working as idlers. Again, all of the rolls are arranged for angular adjustment, and all of the top rolls are adjustable in the vertical plane to accommodate the various tube diameters. This adjustment also provides the means for control of straightening pressure, which must be exerted on the tube by the top roll against the bottom roll. The straightening principle is applied as in the five-roll or the two-roll machine.

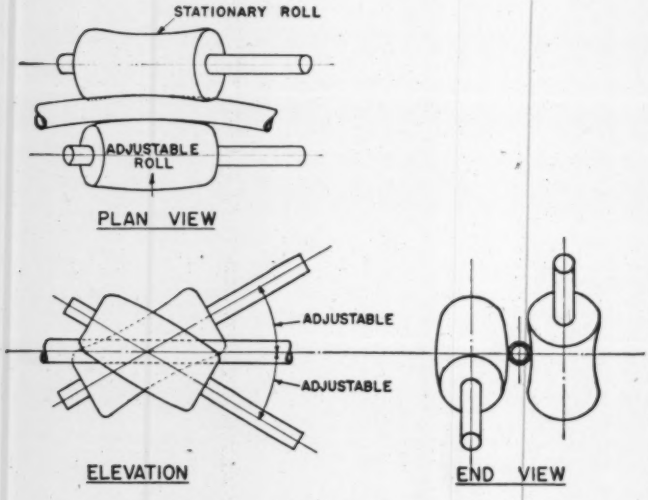

FIG. 7 ANGULAR TWO-ROLL STRAIGHTENING MACHINE

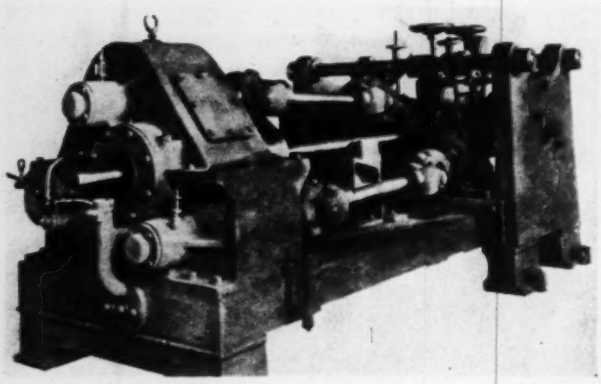

FIG. 8 TWO ROLLS ARE USED ON THIS STRAIGHTENING MACHINE

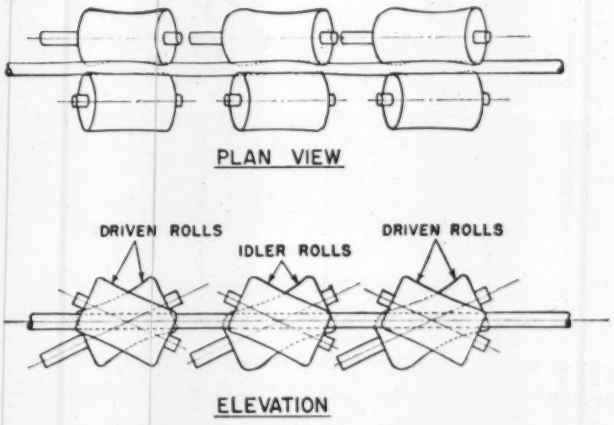

FIG. 9 ANGULAR SIX-ROLL STRAIGHTENER

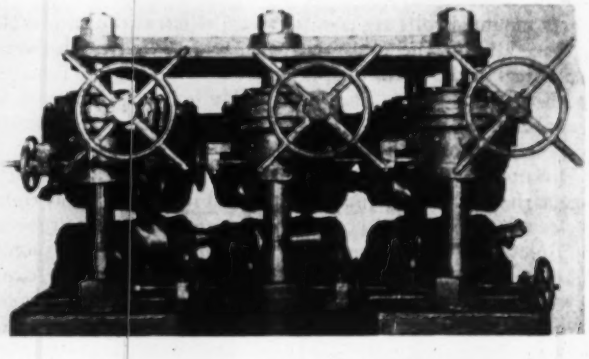

FIG. 10 A NEW TYPE ANGULAR ROLL-STRAIGHTENER EMPLOYING SIX ROLLS

CONCLUSION

The machines used for tube-straightening have been described in the order of their adaptability in industry. It should be kept in mind that conditions vary with requirements. From the foregoing description of the various straightening machines, it becomes apparent that there are only three principal tube-straightening methods, namely, press-straightening, contour roll-straightening, and angular roll-straightening. The same principles involved are also applied to straightening bar stock and rods.

In the welded- and seamless-tube industry, the machines described herein are the most practical. In analyzing the straightening of tubular stock, the familiar bending moment formula $M = PL/4$ is employed.

There are additional straightening methods, such as stretching, applicable to wire, light rods, sheet stock, etc. These applications are adapted in principle to special and specific manufacturing operations.

In industries, where $^3/_{16}$-in-diam and smaller tubes are being fabricated, the conventional high-speed straightening is not practical. Special straightening equipment has been designed to meet their requirements.

STRESS-RELIEF-HARDENING *of* BERYLLIUM COPPER

Unusual Properties Make Many Applications Possible

By ROBERT W. CARSON

CONSULTING ENGINEER, LITTLE FALLS, N. J.

IN THE 15 years since the material was first announced, the unusual properties of beryllium copper have led to a number of applications, many successful and some disappointing. Overenthusiasm and insufficient physical data in some instances have led to failure. Today, however, the available data and information on physical properties and heat-treatment are more complete, and successful applications are found in a variety of products.

Each successful application has required a design based upon the physical properties which are characteristic of the material, as well as knowledge of the effect of heat-treatment on these properties. In no design has the problem been solved merely by substituting beryllium copper for another material.

PROPERTIES IN WHICH BERYLLIUM COPPER EXCELS

No other material combines so many properties so often helpful in design. Beryllium copper is not only as corrosion-resistant as brass and phosphor bronze, but also is nearly twice as strong. It is nonmagnetic. It has endurance strength nearly equal to steel; higher under corrosive conditions. Its electrical conductivity is twice that of bronze and it will maintain spring properties under temperatures 100 F higher than bronze. In addition, it has less tendency to drift or take a set than almost any other spring material. Since it is hardened by heat-treatment after forming, beryllium-copper parts can be made in forms and shapes impossible to duplicate in many other alloys.

One of the important factors behind the successful application of beryllium copper to a variety of products today is stress-relief-hardening or fixture heat-treating. However, this practice usually requires some design changes to capitalize in full on the potential cost savings obtainable. What these design problems are can best be presented by examining some typical applications. The illustrations are representative of products using beryllium-copper components made from wire and strip; many but not all in the form of springs. In each case, fixture heat-treated beryllium copper offers the lowest-cost approach as a primary consideration, although improved performance is also realized in most instances.

FIXTURE HARDENING PROCESS

Fixture hardening is a fairly common practice in some types of steel parts, such as gears and cam shafts, and has been used to a limited extent in special steel-spring applications, but the properties of beryllium copper offer a unique opportunity. By proper selection of heat-treating time and temperature (which may vary appreciably from lot to lot of material), beryllium copper can be thoroughly stress-relieved during hardening. Or expressing the idea another way, the age-hardening can be carried out at a temperature high enough for the elastic strength to become zero. Under such conditions the part "sets" to the shape in which it is held during hardening, and after cooling to room temperature its high elastic properties cause it to retain its shape.

Conformity to a fixture is controllable to a considerable degree by the hardening temperature, and under certain conditions some sacrifice in final elastic properties must be faced when maximum conformity is desired. The higher the hardening temperature, the better the conformity; but hardening heat-treatments above 725 to 750 F usually does not develop full hardness and strength. So, the best heat-treatment is often a compromise. Recommended methods for determining the one best heat-treatment for a given application are described in detail in the several references at the end of the paper.

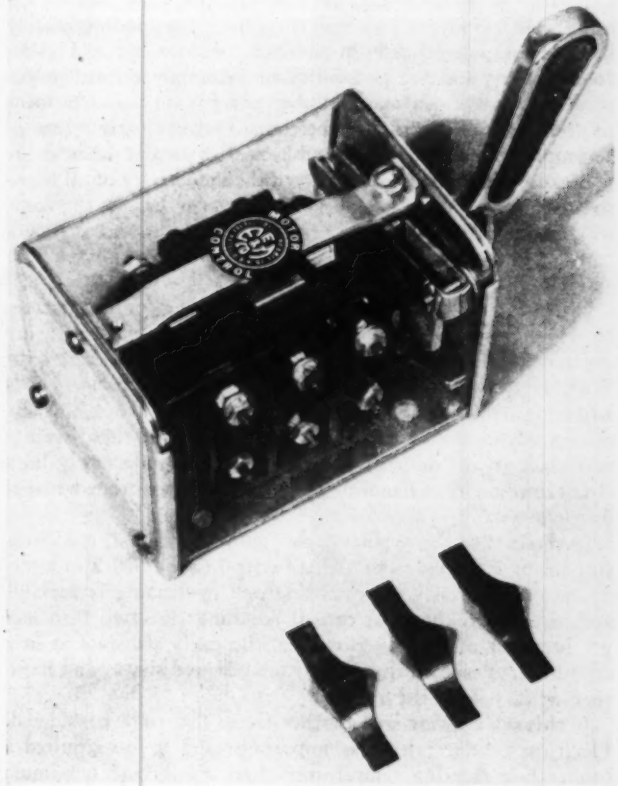

FIG. 1 FIXTURE HEAT-TREATED CONTACT BLADES FOR THIS MOTOR REVERSING SWITCH REQUIRE NO ADJUSTING AND CARRY HEAVIER CURRENTS WITHOUT LOSS OF SPRING PROPERTIES

Contributed by the Machine Design Division and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

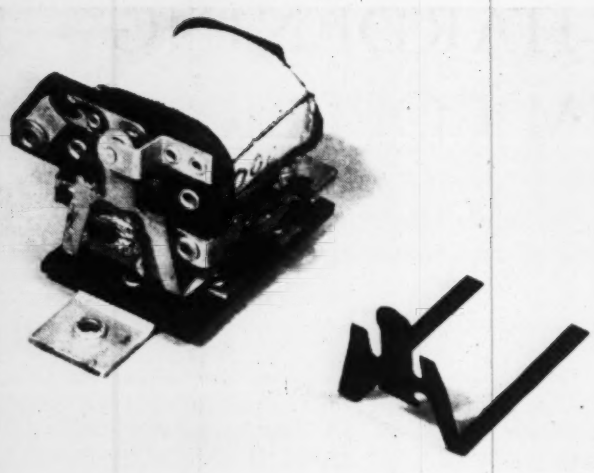

FIG. 2 ASSEMBLED COST OF THIS BERYLLIUM-COPPER ARMATURE SPRING FOR A SENSITIVE RELAY IS LESS THAN FOR THE SAME SPRING MADE OF BRONZE AND INITIAL CALIBRATION IS HELD MORE ACCURATELY IN SERVICE

BERYLLIUM COPPER MADE SNAP-ACTION SWITCHES POSSIBLE

One of the first, and today one of the largest, uses is the spring element in small snap-action electrical switches. The significance of beryllium copper here is that it made the industry possible. The utility of these switches rests on two major factors, i.e., small size, and freedom from failure. Beryllium copper made both available through its exceptionally high endurance strength. However, other factors also played a part. Uniformity in operation required close tolerances and accurately held shapes, as well as high electrical conductivity and resistance to heat, and the possibility of forming intricate shapes accurately in the soft material, depending upon heat-treatment to develop needed spring properties. This is clearly a case of accomplishing a result not possible at all with any other alloy.

Because it has the highest electrical conductivity of all high-strength spring materials, beryllium copper has in the same way made possible a number of developments in electrical controls. The fractional-horsepower-motor reversing switch shown in Fig. 1 is typical.

Other factors also were important; for example, fixture-hardening of the beryllium-copper parts reduced manufacturing costs by more than enough to cover the added material cost. With conventional spring materials for such parts, hand-adjusting had traditionally been accepted as unavoidable. By taking advantage of fixture hardening, each of these springs was made to the desired final shape and had sufficiently high strength to undergo handling and assembly operations without distortion.

In the case of the sensitive relay shown in Fig. 2, the armature spring is formed from $^1/_4$ hard strip 0.008 in. thick in a one-operation progressive die. Springback in forming is variable and, even with the most careful handling, the two thin legs get bent out of shape. However, the parts are stacked in a steel fixture designed to hold the final desired shape, and hardened while held in the fixture.

In this relay spring still another factor had to be considered. Electrical conductivity was important, and it too required a higher heat-treating temperature than one giving maximum spring properties. Therefore this part was purposely overaged with a loss of 10 per cent of its maximum proportional limit in order to obtain good conformity and higher conductivity.

On a direct cost comparison between similar springs made of phosphor bronze and fixture heat-treated beryllium copper, the lower-cost answer for this relay spring was beryllium copper. The piece price was substantially higher, but elimination of the hand adjusting operation required for the bronze part was more than the difference in piece cost. In addition, the manufacturer obtained better life, better conductivity, and higher safe operating temperature.

The electric-range switch, shown in Fig. 3, uses four flat blades to which contacts are attached. Each blade is fixture heat-treated to eliminate hand adjusting operations formerly employed. This is an important cost-reduction feature of course but another factor also is important. Fixture heat-treated blades hold their assembled position more accurately with passage of time and assure that the factory adjustment does not change in service. As compared with bronze, the beryllium-copper blades with higher conductivity and heat resistance permit the use of thinner shorter blades, which reduces the size of the unit and improves its sensitivity. The net result is a more compact, more accurate control, manufactured at lower cost.

MANDREL-COILED SPRINGS

Beryllium-copper coil springs also found an important place in the automatic broiler-control element of the range control Mandrel-coiled springs (another form of fixture heat-treatment) are produced to sufficiently close tolerances to eliminate the need for manual adjustment of this assembly. This not only simplified the design and reduced the number of parts, but cost savings in assembly are more than enough to pay for the added material cost of beryllium copper.

Another cost-reduction application for beryllium-copper coil springs is found in the adjustable pressure controller shown in Fig. 4. This is a bellows-operated snap switch in which the small coil spring is used to provide snap action in the spring blade. For desired control of pressure differential, the force exerted by the spring at its compressed or working length had to be held within 2 per cent. For coil springs produced on an ordinary coiling machine, springback in coiling affected coil diameter, free length, and number of turns, requiring in this application 100 per cent testing and sorting after a careful stress-relieving heat-treatment. How-

FIG. 3 FOR THIS OVEN THERMOSTAT, CONTACT BLADES HEAT-TREATED FLAT REQUIRE NO ASSEMBLY ADJUSTMENT AND ARE UNAFFECTED BY HIGHER OPERATING TEMPERATURES THAN ANY OTHER GOOD CONDUCTING MATERIAL WILL WITHSTAND

(Mandrel-coiled beryllium-copper springs in broil switch, made to precise desired tension, eliminate necessity for adjustment.)

ever, mandrel-coiled beryllium-copper springs are supplied to sufficiently close tolerance to eliminate all this extra labor with a substantial reduction in handling, inspection, and reworking.

Beryllium copper is also the lowest-cost answer to the larger coil spring. Close control of free length plus freedom from drift assure that every spring assembled has the desired load test and will not change in service. The flat blade is beryllium copper too. Fixture heat-treating makes certain that the center tongue is in the same plane as the outer legs to simplify calibrating adjustments. Endurance strength and stability are also important in this part, so the heat-treatment used is a compromise giving the best flatness with minimum loss of endurance strength. The flatness obtainable, however, is sufficient to eliminate completely any necessity for hand correction, and cost savings alone provide adequate justification for beryllium copper.

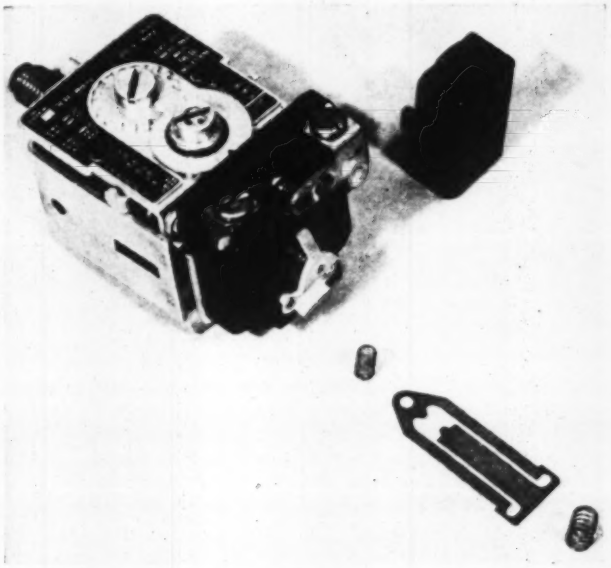

FIG. 4 BY MAKING THE BERYLLIUM-COPPER COIL SPRINGS TO A LOAD-TEST TOLERANCE OF 2 PER CENT, SUBSTANTIAL COST SAVINGS WERE MADE IN THIS PRESSURE REGULATOR BY ELIMINATING INSPECTION AND TESTING LABOR

(The spring blade is fixture heat-treated for heat combination of flatness and endurance strength.)

FIG. 6 THE ROUND STAMPING IS A BERYLLIUM-COPPER SNAP-SWITCH ELEMENT IN THIS TIME-DELAY RELAY, FIXTURE HEAT-TREATED TO REDUCE MANUFACTURING COST AND ASSURE CONSTANT CALIBRATION

(Flat spring is heat-treated for minimum drift.)

Once this pattern of cost reduction has proved itself in an organization, alert designers usually find many opportunities to apply it. For example, Fig. 5 illustrates four different thermostat control units where higher-cost fixture heat-treated beryllium-copper parts are used to obtain lower over-all costs.

In the room thermostat, a flat blade is produced straight enough to require no further hand adjusting. A refrigerator control uses a mandrel-coiled spring held to a 4 per cent tolerance on load at a specified working length, eliminating trial-assembly expense and rejections in final test. In the two other thermostat elements, fixture hardened flat springs contribute

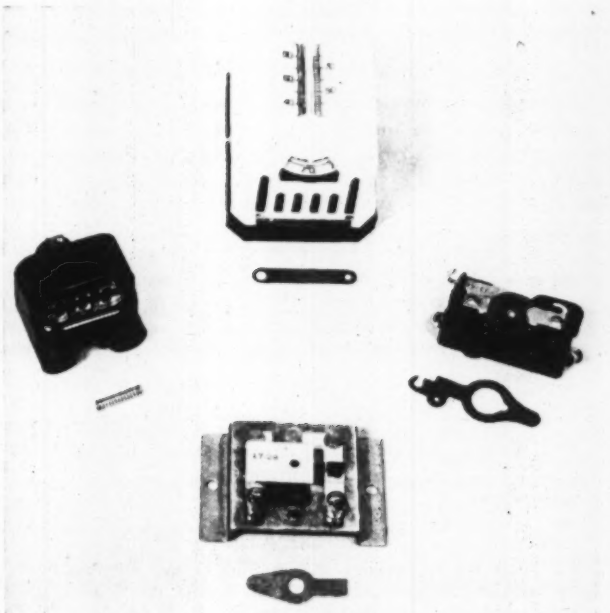

FIG. 5 EACH ONE OF THESE FOUR THERMOSTAT CONTROLS USES FIXTURE HEAT-TREATED BERYLLIUM COPPER FOR LOWER OVER-ALL COSTS, ELIMINATING HAND ADJUSTING OPERATIONS NECESSARY WITH MATERIALS FORMERLY USED

(Better heat resistance and freedom from drift also improve performance.)

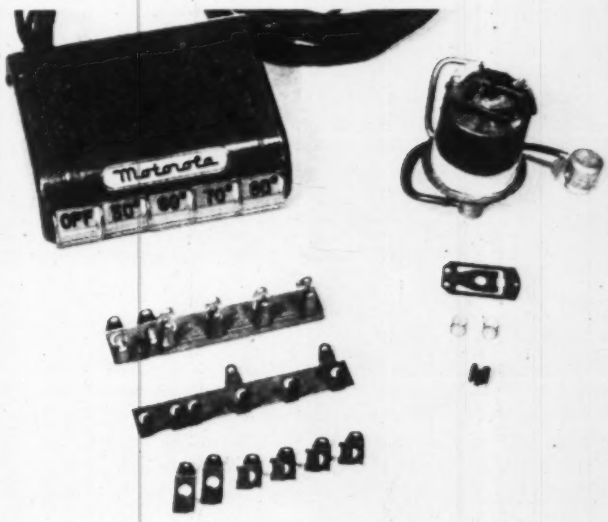

FIG. 7 BERYLLIUM COPPER WAS SELECTED AS OFFERING THE LOWEST MANUFACTURING COST FOR ELEVEN SPRINGS IN THIS AUTOMOBILE HEATER

(Higher material costs were more than offset in each case by reduced adjusting labor, greater uniformity, or freedom from service failure.)

to over-all cost reduction through savings in assembly labor much greater than the small added piece cost.

The same story is behind the substitution of beryllium copper for bronze in two spring elements in the adjustable timer shown in Fig. 6. Fixture hardened parts are produced with sufficient precision to eliminate hand adjusting operations formerly used, with an over-all saving in cost. Performance is improved as well, since beryllium-copper parts are much less subject to change or drift in service.

Eleven beryllium-copper parts shown in Fig. 7 for an automobile heater offer a striking example of good engineering based upon using beryllium copper to cut costs. In the fuel pump at the right, mandrel-coiled valve springs are made to sufficiently close tolerances to eliminate testing or selective assembly with a cost saving justifying a price for beryllium-copper springs several times the cost of an ordinary spring.

This pump is operated by a solenoid controlled by the snap-action switch at the top. Its endurance strength put beryllium copper in the flipper blade, while a fixture heat-treated W-spring gives more uniform and faster snap action than obtainable with a similar part in bronze.

In the push-button control unit for this automobile heater, phosphor bronze had been selected for the contact assembly operated by the push buttons to control the line switch and four preset thermostats. It is usual practice in such assemblies to hand-correct in inspection jigs for variations in form of individual springs and for distortion of parts incidental to handling and assembly. Fixture heat-treated beryllium-copper components are produced to sufficiently close tolerances to eliminate all hand work, and the higher strength of the alloy prevents damage in handling and riveting.

Fig. 8 shows the heat-treating fixture for one of the parts in this assembly and also discloses another important cost-reduction possibility developed through beryllium copper. By shearing only partially through the material at the cutoff stage in the punch-press die, the parts are produced in a continuous length. After hardening the strip, individual springs are readily snapped off as needed. By leaving the springs in a string, the operation cost of riveting the silver contact button

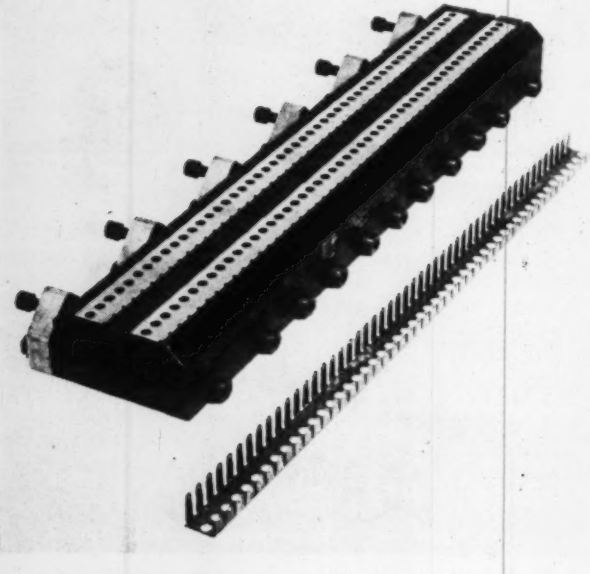

FIG. 8 ONE OF THE PARTS SHOWN IN FIG. 7, AND ITS HEAT-TREATING FIXTURE

("Springs in a string" save handling and untangling expense, both in loading this heat-treating fixture and in riveting and assembly.)

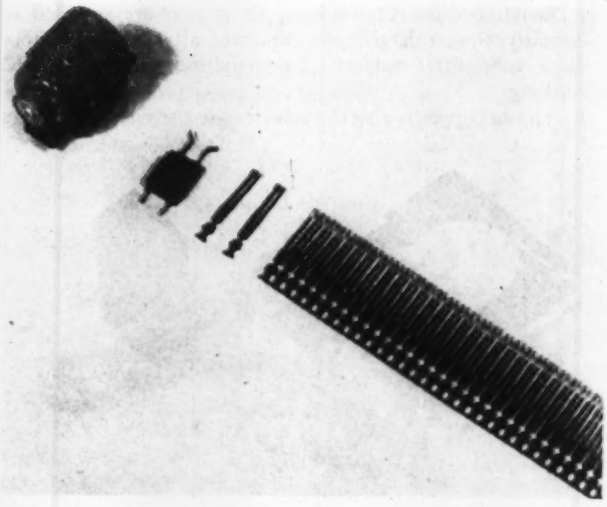

FIG. 9 KEEPING THESE MOTOR BRUSH SPRINGS IN A STRING DURING HEAT-TREATMENT, SHIPMENT, AND DELIVERY TO ASSEMBLY BENCH ELIMINATES COSTLY TANGLING AND DAMAGE TO PARTS

is reduced, as well as inspection and handling cost. In this application, cost savings with beryllium copper are great enough so that phosphor-bronze parts cannot be considered.

Several high-production applications have been made for this idea of springs in a string (see Figs. 8 and 9) as a cost-reduction measure.

This motor, illustrated in Fig. 9, uses a small molded assembly incorporating two identical springs. The "springs in a string" idea solved a serious problem of tangling which not only required a great deal of hand labor, but also resulted in a considerable amount of unavoidable damage to parts. Cost savings in handling alone justified beryllium copper, while the greater uniformity in formed dimensions was an important element in motor performance.

DESIGNING PARTS TO TAKE ADVANTAGE OF BERYLLIUM COPPER

Making use of opportunities beryllium copper offers in such applications as the ones described requires a fundamentally different approach to design. In all of these devices illustrated, substantial over-all savings in cost were obtained even though the cost of the parts was much greater than for ordinary materials. In each case beryllium copper was the lowest-cost answer. In most cases there were other advantages obtained by proper design use of the higher physical properties of hardened beryllium copper.

For more specific data on applying the technique used in fixture heat-treating beryllium copper, the references cited may be of interest.

ACKNOWLEDGMENT

The author acknowledges the assistance of Instrument Specialties Company, Inc., in providing the illustrations used in this paper.

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MECHANISMS *of* METAL CUTTING

Frozen Motion or Chip Contours as a Clue to Process of Chip Formation

By W. H. OLDACRE[1] AND H. A. ERICKSON[2]

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THE possibility that the contours of chip shapes and structures may hold clues to the intricate mechanisms of metal cutting has for several years been a challenge to the authors of this paper.

When it is considered that a comprehensive knowledge of geological history has derived from the study of fixed rock formations and acceptable theories of the processes of their development have resulted from a careful analysis of such information, it does not seem too far-fetched to anticipate that a careful study of chip convolutions and structure may add greatly to our present limited knowledge of the mechanisms of their formation.

Neglected and discarded as scrap, the chip is in fact the real product of the metal-cutting process, as the workpiece is the residuum remaining after the completion of the necessary chip production. Metal in the chip is severely deformed in the processing, and it seems logical to expect that the magnitude and direction of the forces involved are reflected in chip contours.

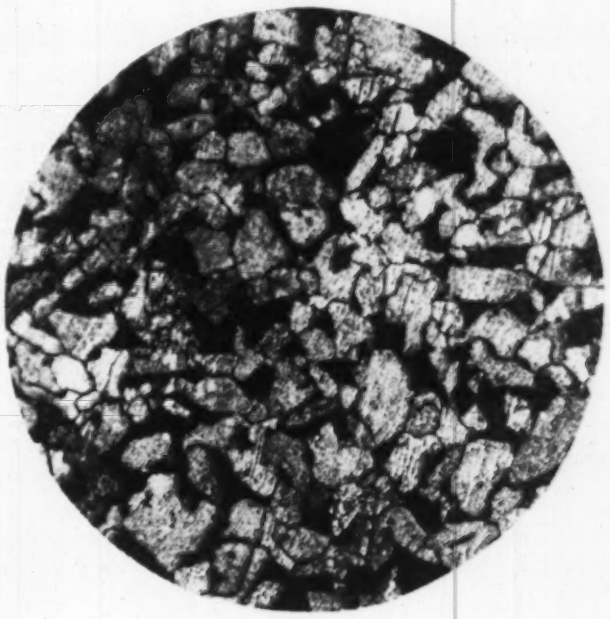

FIG. 1 MICROSTRUCTURE OF LOG, AISI C-1019 COLD-DRAWN NORMALIZED STEEL; ×100

Machining studies are confused by the obvious: Chips curl off so easily from the tool edge; they slide so surely over the tool faces; they are so obviously heated by the frictions and tortures attending their development; and the resulting high temperatures are so certainly injurious and undesirable. Such superficialities guide most theories of metal cutting, and it is indeed surprising that practice moves so surely with so little illumination from scientific sources.

Even a perfunctory inspection of a number of different chips discloses tremendous variations in their organization, and clearly indicates the intricate complexity attending their formation. Under the microscope these complexities are vastly increased.

The work covered in this report is frankly exploratory and preliminary. Results are not in any sense conclusive, but seem interesting and are offered in the hope that others will perhaps be challenged to turn their attention to this promising subject.

Much metal-cutting research has revolved around the use of the single-point tool. While in operation apparently simple, this tool is in fact complicated, as more than one edge and a radius or corner are involved in the cut. Chip flow is confused by interferences due to conflicting angles, and, therefore, resulting chips are analyzed only with difficulty.

SINGLE-EDGED TOOL USED IN TESTS

The straight single-edged form tool appears to be much simpler in operation, and the chips correspondingly easier of analysis. For this reason a straight $^3/_8$-in. high-speed tool bit mounted in an Armstrong toolholder was chosen for the present study. The edge was carefully ground and stoned with an effective end relief or front clearance angle of approximately 15 deg, and the top or back-rake angle of approximately 14 deg. A section of 4-in. cold-drawn and normalized AISI C-1019 steel was available, and, as previous work had indicated that a fairly satisfactory microscopic chip structure resulted when it was used, it was selected for this investigation (Fig. 1). It was mounted firmly between centers in a 14-in., sliding-gear-head, toolroom and engine lathe. Lands $^1/_8$ in. wide were previously prepared by grooving the log to the depth of approximately $^1/_2$ in. as shown in Fig. 2. An infeed of 0.0014 in. was used as being a representative forming cut for this type of material, and six speeds readily available on the lathe were investigated.

At the start of each cut, the tool was located with the land approximately in the center and just barely clearing the edge. The cross-slide was allowed to advance 0.005 in. and then the chips were caught in a pan while it advanced the next 0.010 in. During this period, over 7 ft of chip was produced. A different land was used for each speed, and it is felt that the chips collected were produced under nearly identical conditions. Owing to the size of the log, revolutions per minute (rpm) and surface feet per minute (sfm) are approximately the same.

CHARACTERISTICS OF CHIPS FORMED

Fig. 3 shows the chips as collected for the six speeds of 47, 110, 171, 212, 342, and 536 rpm, respectively. The difference in

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[2] Chief Engineer. Mem. A.S.M.E.

Contributed by the Special Research Committee on Metal Cutting and Bibliography and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

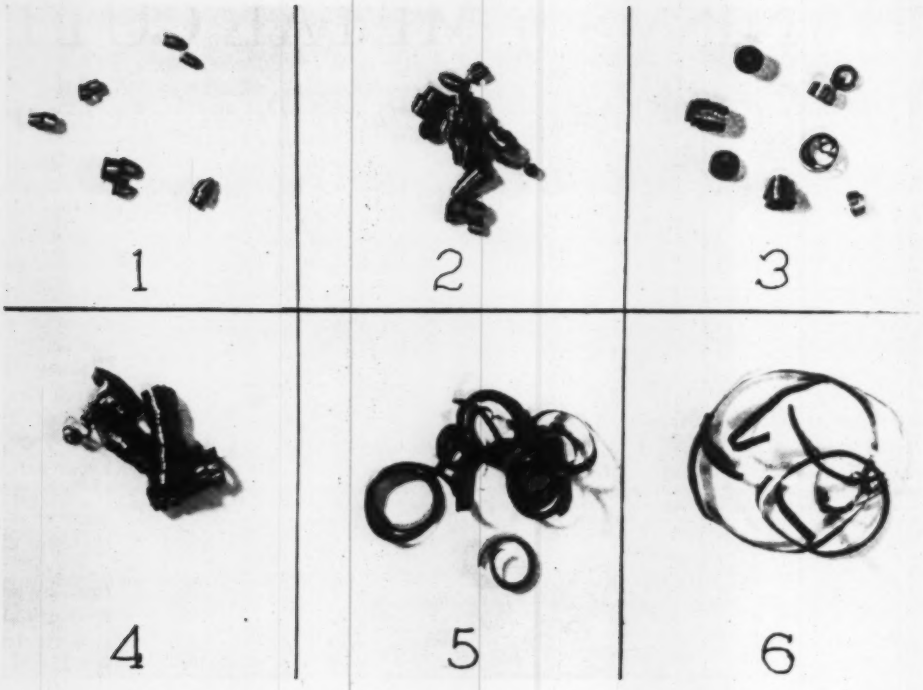

FIG. 3 CHIPS COLLECTED AT SIX DIFFERENT LATHE SPEEDS

(Chips = 1 at 47, 2 at 110, 3 at 171, 4 at 212, 5 at 342, 6 at 536 rpm. About $^{3}/_{4}$ size.)

curl or curvature is strikingly obvious, progressing regularly from the small tight spiral of the low speed to the very open almost straight chip produced at 536 rpm.

Chip sections were conventionally mounted in bakelite, but care was taken to insure that they remained perpendicular to the face of the mount in such a manner that polishing would reveal a representative lengthwise section of the chip. Another piece was mounted in the same block to reveal a cross section. After polishing, the specimens were given a nital etch.

Fig. 4 is a composite representation of six photomicrographs showing the structure of the lengthwise sections of the chips. It has been anticipated that there would be a progressive change in dimension, particularly in the thickness of the chip, as such is seemingly apparent from an inspection of the original chips. The photographs, however, showed little consistency in chip thickness, and the reason for this is evident in Fig. 5.

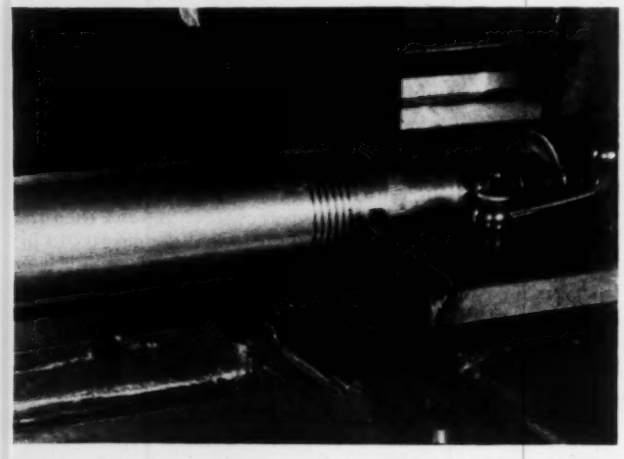

FIG. 2 LOG AND TOOL SETUP

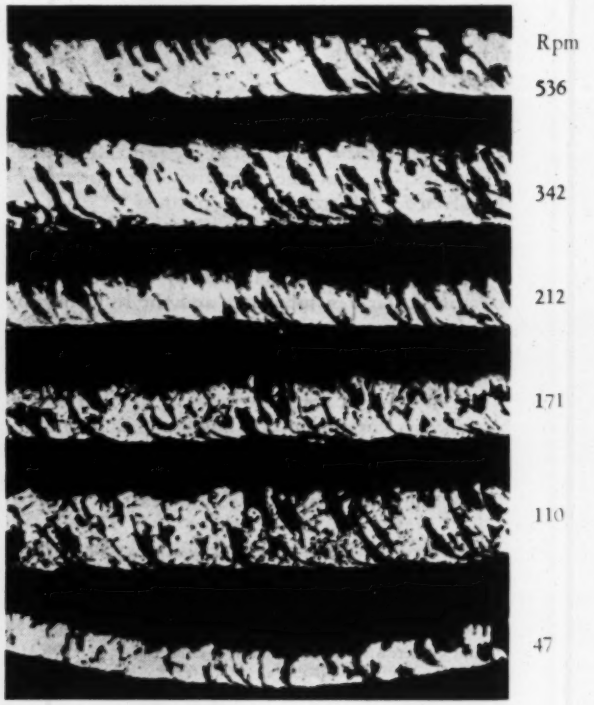

FIG. 4 LENGTHWISE SECTIONS OF CHIP

(Nital etch; ×250.)

Here is a magnification of the inside surface of the chip together with a cross section, and an etched lengthwise section shown for purposes of comparison. Irregularities are striking and the chip thickness varies greatly over the width of the chip. Obviously, more precise means of mounting and measurement will be necessary before truly representative comparisons can be made.

In spite of their faults, however, the photographs are revealing. The well-known layer-built structure of the chip is clearly shown, and variations due to cutting speed are definitely indicated. In comparing the layers, the authors considered each as consisting of three parts, which for convenience and more or less fortuitously were termed, the "slope," the "radius," and the "drag." Fig. 6 represents one of the sections or elements and indicates the angle of the slope, the angle of the drag, and the dimension of the radius, which were studied.

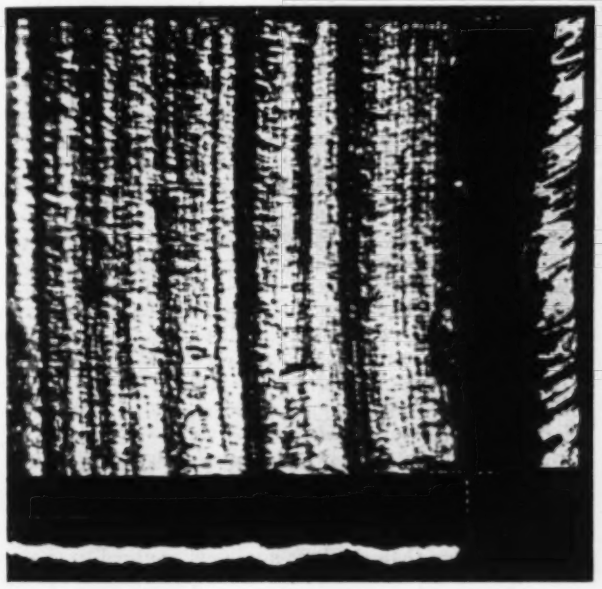

FIG. 5 INSIDE SURFACE OF CHIP AND CROSS SECTION; ×50. ETCHED LENGTHWISE SECTION; ×250

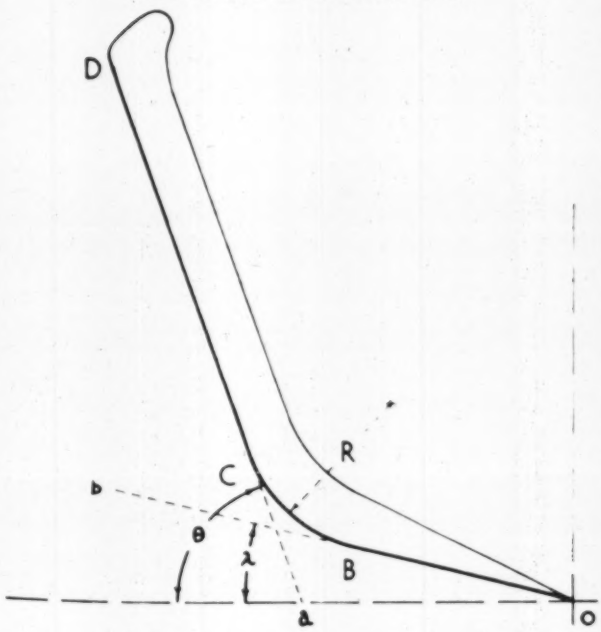

FIG. 6 DIAGRAM OF CHIP ELEMENT OR SECTION

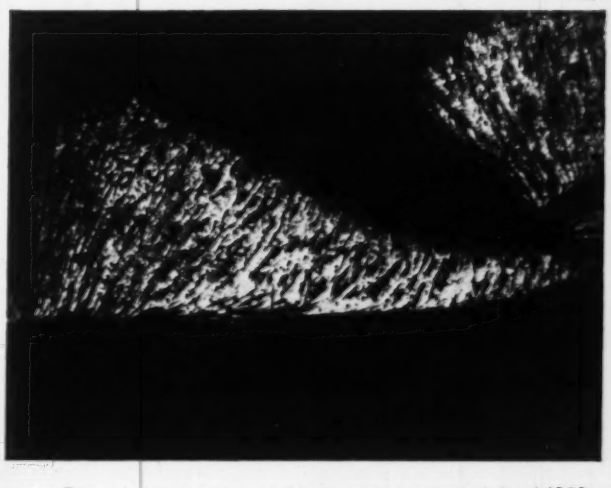

FIG. 7 STRUCTURE OF SERRATION FROM CHATTER CHIP; ×250

While not too apparent in the photographs, the work definitely indicated the possibility that with increased speed the angle of the slope, the length of the radius, and the angle of the drag decreased. In fact, at the slow speeds the elements seemed to be curved throughout their length, and therefore might be said to consist wholly of radius, while at the high speeds, the curvature is very sharp, and the slope and the drag approach a straight line.

Much more precise work will be necessary before the facts can be definitely established, but they seem to afford an interesting basis for future study.

In the course of setting up the test, many interesting phenomena were observed. Fig. 7 shows a lengthwise section of a chip resulting when an infeed of 0.005 in. at 536 rpm was inadvertently used. Very severe chatter developed and the peculiar chip irregularity resulted. While the chip was continuous, it was severely serrated, and the illustration is a magnification of one of the sections. Structural build-up is progressive and cumulative, and is difficult to explain on any basis other than that the metal was freely flowing during the period of development. In fact all of the structures of chips seem to be more easily associated with the behavior of fluids than with solids. As a matter of interest, it may be noted that under similar conditions with a feed of 0.003 in. the chatter was still excessive and the chip wavy, but the serrations were not so pronounced.

CONCLUSION

Results of this investigation confirm the assumption that much can be learned from a careful study of chip structure and further research is already under way. On the basis of this work, it would seem that a work material should be sought which will through a finer structure show chip contours more clearly. Also, a more precise method of mounting will allow the more accurate positioning of the chip. Accurate measurements may then be made with assurance. Further, it is hoped by plating or other surface preparation of the chip to preserve surface irregularities more perfectly. The use of other etchants should reveal different aspects of chip structures and more precise means of representing the structural contours should be developed. Already some progress has been made in attaining these ends and it is hoped to present better results in future reports.

THE GREAT DELUSION—WHERE MARX WENT WRONG

By C. E. WILSON

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OUR American concept of a free society is being importantly challenged by those who subscribe to Marxism, not only abroad but even here in the United States. Through propaganda and fifth-column activities, the thinking of some of our fellow citizens has been warped to the point where they question our American concept of a free society.

The great delusion of those who subscribe to Marxism is that a people will be happier and more prosperous in some communistic or socialistic form of society based upon Marxist philosophy than they can or will be in a free society based upon the fundamental principles recognized by the founders of our Republic.

Our Americanism is still the new, revolutionary, liberal philosophy in the world. Those who advocate communism, socialism, or any form of statism, while flying the flag of liberalism, are in fact advocating a system of society which if put into effect would again enslave the peoples of the world.

MARXISM A CENTURY OLD

In a recent broadcast Samuel B. Pettengill recalled that it was 99 years ago that Marx and Engels wrote the Communist Manifesto which began with the words, "A specter is haunting Europe, the specter of Communism." Mr. Pettengill remarked that this sounds like today's newspapers. He pointed out that the manifesto was written one year before gold was discovered in California and before the covered wagons began to roll across the plains. There are other important things to recall in order to fix the conditions of that time in our minds. Slavery was still an accepted institution in many of our states. In Russia the great majority of the people were serfs bound to the soil. Only half of the babies born in Europe lived past the age of two years, and the same was true in some sections of America. Steamboats and railroads were still curiosities but their use was growing rapidly. Mechanical power was coming into its own. The industrial revolution was on its way. The time we are talking about was approximately 100 years ago. Many of us can remember the last half of this period. While mechanical and scientific invention is continuing at a rapid pace today, politically a great step backward has been taken. We again have slavery in Europe and a new form of serfdom where men and women are bound to their jobs and their machines if they are to have food cards and eat. It is true there are new dictators who give new reasons for enslaving the people, but the result to the people is the same.

In the latter part of the 18th century two great inventions were worked out which have had a profound and continuing influence on the whole world. They have had their greatest development and fruition in our country, and together they have made possible our American comforts, culture, and freedom from want. One of these, broadly speaking, was mechanical and started with Watt's invention of the steam engine. The other was political—the American Constitution which was self-perpetuating, made possible the maintenance of law and order, and at the same time put effective limits on political power. The development of mechanical power, and the development of the physical sciences that went with it, substituted slaves of iron and steel for human backs. Our political invention, which is based upon the religious concept of the sacredness of the individual, has given our people personal freedom which has fulfilled the hope and aspirations of generations ever since the dawn of civilization. In our political system the state is the servant of the people; the people are not the serfs of the state. Our system with public education and individual freedom for all citizens promoted the initiative of millions and greatly accelerated scientific discovery, invention, and the exploitation of natural resources.

When the Founding Fathers established this country, they attempted to establish a form of government under which each individual would be as free as possible to manage his own personal affairs, without interference by others, and least of all by politicians. The Founding Fathers had a great distrust of the competence of politicians in economic affairs. All of them were steeped in history. All of them had first-hand experience with planning of their lives by the political planners in London. That was exactly what they revolted against. They made up their minds to establish a government in this country on a basis in which politicians would have no such power in economic affairs—no more than the bare minimum required to preserve order in civil life and protect the country from attacks. The formula and principles adopted to accomplish this constituted a revolutionary political invention. Under this formula, combined with the spirit of our people, their opportunity to develop a vast continent on a basis of free trade, and with new tools that technology was constantly giving them, this nation grew faster in population, health, and wealth than any other in history.

EUROPEAN CONTRAST

When Marx wrote "Das Kapital," the bible of the communists and the socialists, the situation of the people generally throughout Europe was miserable. This was partly due to a long series of wars and conflicts. Marx accurately reported the grim conditions that existed in Europe a century ago. In England women pulled canal boats along the towpath with ropes over their shoulders. They were harnessed like beasts of burden to cars pulling coal out of British mines. In the textile mills children began work when they were nine or ten years old and worked twelve to fifteen hours a day. It was said that the beds in which they slept never got cold, as one shift took the place of the other. It was said that they were machines by day and beasts by night. Tuberculosis and other diseases killed them off like flies.

Conditions were terrible. Not only Marx, but warm-hearted men, such as Charles Dickens, Ruskin, and Carlyle, poured out a literature of protest which was read around the world. On these facts Marx can scarcely be challenged. But his diagnosis of the trouble was wrong and therefore the remedy he prescribed was wrong, also.

Marx said these terrible conditions were due to greed, ex-

Address presented at the Semi-Annual Meeting, Chicago, Ill., June 16-19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

ploitation, the theft by the owners of the mines and mills of the "surplus value" produced by the workers. That was his diagnosis, and therefore his remedy was to preach the gospel of hate, of the class struggle, of the forced redistribution of wealth, of the confiscation of property, and its ownership and management by the state which, whether he knew it or not, would necessitate dictatorship by the state planners and political powers.

Now, if his diagnosis and remedy were, and still are, correct, we would have no business opposing communism either abroad or in the United States. We should advocate it. I am sure I would be a socialist if I thought the American people would be happier or more prosperous under some form of Marxist philosophy whether it was communism, fascism, or some other form of statism. But I am sure they would not be happier, and I know they could not be more prosperous. With such a clear example of what this Marxist philosophy when accepted by nations does to a people, and with the facts of what our American system of individual liberty has done for our people, there can be no doubt on this point by anyone who looks at the facts squarely. As nearly as I can tell, Mussolini and Hitler did only the kind of things they thought they had to do in their effort to make statism work once they had committed themselves to this philosophy. This also explains the iron curtain and the other acts of communist states which Americans find so hard to understand.

The diagnosis of Marx was correct on one point. "Man's inhumanity to man" has always been a factor in human affairs. Greed can never be defended whether in business or government. Sympathy for the underdog will always be commendable and is part of the concept of a free society. But there is a great difference between being social-minded and being socialistic. Socialism, when put into effect, means some form of statism which, while claiming to operate in the interests of the common man, winds up by ruthlessly disregarding the rights of individuals. A communistic or socialistic government must replace the positive incentives of a free society with the negative incentives of fear and coercion. Greed and exploitation are not cured by socialism.

But even greed was not the main reason for the conditions which Marx described. If all the wealth of the owners of the mines and mills had been redistributed to the workers, it would have relieved their condition but slightly, and for but a little time. And what is equally important, some other method of collecting capital and promoting enterprise would have had to be found. It takes no brains or initiative to stop a going activity, but it takes plenty of brains and initiative to organize and start one to take its place. So, the class struggle, as the remedy for such conditions, is wrong.

THE DIFFICULTY AND ITS REMEDY

What was the real difficulty and what is the proper remedy? The real difficulty was the low productivity of the workers, since workers can be paid only out of production, whether in England a century ago or in Russia, China, and India today. Since the dawn of civilization, man has had to struggle against Nature for food, shelter, and clothing, and even in our time in only a few countries representing perhaps not more than 20 per cent of the population of the world, have all the people ever had all they wanted to eat.

Wages must be low and hours of production long, and the standard of living low, when production is low. Production is low when tools and equipment are poor, and the work is not well organized by management. Then human backs have to do what slaves of iron and steel do today in America. Tools are poor when capital has not been accumulated to buy better tools.

One hundred years ago freedom had so recently emerged from centuries of tyranny that the educators, statesmen, inventors, scientists, and business men had not had a chance to dream and plan. Neither did they have the freedom of action we have had in our country. The political systems of most nations were still promoting the dictatorship of the few and restricting the free initiative of the millions. For more than 150 years, free men here in America have had the opportunity to educate themselves, select their own occupations, accumulate capital, and invent better ways of doing things. This is why the people in the United States are so much better off than the people in the rest of the world. This is why we never have had a real famine in our country. This is why our standard of living is about nine times as high as the average of the people of the rest of the world. This is why we were able to serve as the arsenal of democracy and assume the major role in the rehabilitation of our enemies as well as our friends.

Such attainments cannot be explained on the grounds of greater natural resources in the United States nor of racial superiority. The answer lies in the simple fact that we have done a better job of applying our human energy and individual initiative to the improvement of the welfare of all. Our political system is the single important factor which makes the difference between our country and others.

In my own experience and memory I have seen the most rapid increase in the standard of living of a people ever achieved anywhere in the world. This is why I am so sure that our American system of free competition and industrial development is sound. I have seen what it produced. I have seen what it can do. I have seen my own friends and neighbors profit by it. I have seen a free people meet two great war emergencies. I do not understand how anyone who has thought about the matter and who has witnessed all of these developments, starting with the great home improvements of modern plumbing and electric lighting, and followed by the automobile, airplane, household appliances, and radio—the things that have added so much to our comfort and pleasure in living—can believe that our system is fundamentally wrong. Nor do I understand how anyone can feel that industrial progress has been made at the expense of social progress, nor why any American should suffer from the great delusion that any form of communism or statism, which promotes the dictatorship of the few instead of the initiative of the millions, can produce a happier and more prosperous society.

FALLACIES OF MARXISM

To list the principal fallacies in the communist doctrine of Karl Marx:

1 He put all the blame for the low standard of living of the mass of the people 100 years ago upon the greed of those who had achieved ownership of productive property, and he did not recognize the fundamental concept that, without some incentive, capital would not be accumulated to provide the superior tools man needed in his struggle for food, clothing, and shelter.

2 In his Communist Manifesto, Marx said, "The theory of the Communists may be summed up in the single sentence, 'abolition of private property.'" He either had no respect for the fundamental rights to freedom on the part of the common man or he did not realize that there could be no individual freedom with the right of free choice in personal activities and affairs without private property.

3 He overlooked the fact that no man or small group of men with dictatorial (political) power could plan for all the people as well as the people could plan for their own individual lives if they had a political system which was flexible enough to allow them to do so, while at the same time maintaining law and order. A free competitive society has within itself the power to correct its mistakes through the ordinary functioning

of free competition while, with a one-party autocratic state control, the dictators force the people to suffer with their mistakes and like it.

4 One of his principles is expressed by the catch phrase, "From each according to his ability; to each according to his need." As an ideal this may seem sound social philosophy, but there is no practical way to implement this doctrine. In a communist state how do you get those of superior ability or capacity to put forth their maximum effort, and how do you identify them or put them in places where they can function to the best of their abilities when they have no free choice or any individual incentive? Likewise, who is going to determine the need of lazy or below-average citizens as compared with the industrious and more intelligent.

Several years ago I was talking to one of my uncles about the problems of the country and he said he had always remembered a remark made by one of his professors at Mt. Union College. Dr. Schunk, his professor, said, "The real problem of a democracy could be stated in one short sentence: 'What shall we do about the idle rich and the worthless poor?' " He said this about fifty years ago. In the last two decades some people in this country seem to think that the problem is, "What shall we do about the worthless rich and the idle poor?" From my own point of view good citizens do not belong to either group stated either way. Actually, in a free society where industry and thrift have their reward and laziness and dissipation pay their penalty, and a social consciousness has been developed for the unfortunate, the best solution for this problem ever achieved in the world has been worked out.

5 In his communist doctrine Marx made no provision for promoting real progress in economic and human values. If communism or socialism could function at all with reasonable satisfaction it would be in a primitive society based almost entirely upon agriculture. Any form of communism or one-party statism inevitably, in order to maintain law and order, must replace the positive incentives of a free society with the negative ones of fear and coercion. This inevitably suppresses the initiative of the millions of citizens and tends to develop a frozen society which can make little or no progress in developing the finer things of life; in other words, a society of bees and ants.

PRODUCTIVE PROFITS

One of Marx' greatest fallacies was his claim that the total value of goods produced belongs exclusively to the manual labor engaged in its production, and that the withholding of the "surplus value" of the product, commonly known as profits, constitutes robbery. "Surplus value" is not primarily the product of manual labor. On the contrary, it is the product of intelligence—intelligence in the use of resources, in the development of technology, and in the organization and management of our economic groups—all within the framework of our constitutional formula of limited government and personal liberty. A simple illustration will demonstrate this. In a free society and in the absence of slave labor or some other form of coercion, a successful management takes materials and labor at the market price and produces a new product having a greater value than that of the sum of its parts. That greater value was not even in existence before the process. It did not and could not exist except for the process. So the greater value was produced by the process and not by the ingredients going into it.

The attack on profits as such is one of the things that is poisoning the confidence of some of our fellow Americans in our system. In the final analysis this attack is really an attempt to substitute socialism or communism for our free competitive and capitalistic system.

As every American knows, an integral part of the capitalistic economy is the profit system; or more strictly, the profit and loss system. Hope of profits and fear of losses are principally what makes capitalism work. Precisely because they are so much the key to its operation, a large part of the attack on capitalism in recent years has been directed at profits.

Webster defines profit as the "excess of returns over expenditure." In the capitalistic system this is only part of the definition: It completely ignores the dynamic role that industrial profits play in the economy. The important thing is that the hope of profit is what gets the job done with the minimum expenditure of man-hours and materials.

THE INCENTIVE OF COMPETITION

In a normal competitive market the selling price of goods is finally determined by competition. The only way a producer can make a profit is to increase his efficiency, thus reducing his cost, or to improve the quality of his products, thus making them more salable. But if this process produces a more than adequate profit, one or more competitors will reduce prices or make their products still better in order to obtain a larger share of the business. Thus there is a continual pressure to improve the quality of products and reduce their cost, and the people as a whole profit thereby. It is obvious that in a free market there cannot long exist that darling of the anti-business propagandist, the "exorbitant" profit. Only under very unusual conditions can profits be large for any length of time.

We can all have more only if we produce more. Increases in productivity are not automatic, nor are they, generally speaking, the result of increased efforts by workers. They result from improved tools, new processes, and new inventions, and these come about because someone is willing to save part of his current income and risk it in financing new developments—all in the hope of making a profit. Technological progress in total seems slow, but the results are highly important. They have been so great that on the average in our country each generation has had about twice the standard of living measured in goods and services enjoyed by their fathers.

Between 1849 and 1939 investment in industry per worker increased from $500 to $6000. In 1877 a worker had only 1.3 horsepower in the form of power machinery to help him produce. By 1939 he had 6.4 horsepower.

The steady rise of hourly wages of workmen, more leisure time due to a progressive shortening of working hours, and the increased social benefits in which we all share—better health, better recreational facilities, better educational facilities—give the lie to Marx and all those who subscribe to his hatred of a free society.

Free enterprise and its essential elements can be compared to an automobile engine and its parts. Savings and credit are the flywheel, banks and financial institutions are the crankshaft balancers, and the lubrication system. Confidence is the self-starter. The hope of a profit is the spark plug and ignition system and the fuel used is the productive effort of all of us who work. The octane number of the fuel is raised through education, initiative, and attitude toward work. At present some people feel that the fuel has a pretty low octane number which cuts down the power of the engine and makes it knock a bit.

As efficient and useful as this free-enterprise engine is, I still believe that it can and will be improved just as I believed twenty-five years ago that the rough and at that time somewhat inefficient four-cylinder motorcar engines, that we thought were so marvelous, could be improved. But I am certainly against discarding this proved efficient engine that gave the American people the highest standard of living in the world and replacing it with some imported type from east of the Rhine, or even from England—as, for example, the jet engine—which has only one spark plug, the state, and depends for its power on a blast of hot air.

INVENTION *in* ENGINEERING DEVELOPMENT

By D. W. McLENEGAN

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DURING this centennial year much is being written about the inventions of Edison. Far less attention is being directed to the thorough painstaking courses of analysis which led Edison and many others to the threshold of new discoveries and to their useful application.

The purpose of this paper is (*a*) to consider the place of invention in the development of new products or systems; (*b*) to examine some of the qualifications of an engineer which lead to the creation of new and useful results.

THE SCOPE OF INVENTION

From the strict standpoint of patent law, an invention may be considered complete as soon as a reduction to practice is made. This may consist of building and testing a full-sized sample which demonstrates the workability of the new scheme, or simply the filing of a patent application resulting in a patent which makes clear to "those skilled in the art" the points of novelty involved and a means of accomplishment. The economic value of the invention need not be proved. To an engineer engaged in the development of improved goods for more widespread use, defining a new idea in a form which is possible is only the first stage of a development to bring the idea to useful form. His creative effort, whether patentable or not, continues throughout the process of refining the idea into a finished product.

THE VALUE OF A NEW IDEA

The conception of a new idea or a significant improvement does not in itself create new wealth or advance the standard of living. The term "paper patent" is often used to describe the many patents claiming inventions which for lack of immediate economic value or adequate development effort have failed to generate any useful result. Until it is developed, a new idea is of value only as it serves to stimulate the inventor to set about its development for practical use, or to stimulate other workers in allied fields, perhaps touching off a chain reaction of further ideas for exploitation.

The timeliness of an invention may determine whether prompt and vigorous development is justifiable. The mechanisms needed for exploitation may be ready in suitable forms, or the idea may be far ahead of its time. When the electric starter for automobiles first appeared, the industry was already reaching large production, and the need soon became well established. The public was ready for such an improvement, and the technique of the electrical industry was sufficiently advanced to afford reasonably compact reliable motors, generators, and batteries. Hence the use of this idea developed rapidly.

In contrast, Lord Kelvin wrote in 1852 that the elements of a refrigerating system could be transposed to permit its use for both heating and cooling. The refrigerating machines of that day were rudimentary and bulky; the electrical industry had not yet appeared, and the central heating of buildings had not yet superseded the use of stoves. So the "heat pump," or reversed refrigeration cycle, was largely ignored until a comparatively recent date. The late Dr. A. R. Stevenson, Jr., in 1926 called attention to its potential usefulness; even today, the broad development of this idea is still in an early phase.

ENVIRONMENT FAVORABLE TO INVENTION

Thus the prospect of a profitable business result determines largely whether a new concept will be followed by active development. In fact, this prospect largely charts the course of creative engineering.

Invention in the field of engineering is seldom the result of isolated inspiration, nor is it the starting point in most engineering developments. Instead, it is more likely to occur where broad objectives have been established, where the engineer not only understands these aims but has carefully studied the various aspects of the problem and become familiar with past thinking and current progress in his field. A knowledge of other fields will broaden the perspective with which he analyzes his problems.

The creation of a new or improved product commonly involves the following activities in which various individuals or groups may participate and contribute stimulating points of view:

Consideration of the end results desired beyond existing practice.

Study of the field or market to be served, to define the environment in which the new product or result will be applied.

Conception of the means or combinations which will produce the desired results.

Establishment of willingness to accept new practices.

Analysis of proportions, performance, and limitations.

Specific design for manufacture.

If the engineer possesses a broad perspective of his industry he can be an important contributor in every stage of this process. Each of these steps represents the analysis of a problem, differing only as to the terms in which the answers are to be expressed. The opportunity for creative thinking exists throughout and is not limited to the stage in which the ideas first assume physical form.

One might say that the turbosupercharger for aircraft engines was almost an inevitable development, and that the major creative activity in this development lay in working out the problems since the basic idea of the gas turbine was first disclosed in 1791. The power of early aircraft engines was inadequate, particularly at the higher altitudes; a source of energy was available in the exhaust gases; hence the supercharger with the gas turbine as its motive power followed as a logical step to increase the power available at high altitudes. The late Dr. S. A. Moss, who was justly honored for his contri-

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butions to the turbosupercharger, described (1)[1] its early progress as a series of reasoned improvements. A number of patents emanated from this work, but his description infers that these resulted as much from thermodynamic analysis as from pure invention.

It may be said that Dr. Moss's great contributions were made because he had vision to see what the turbosupercharger might accomplish, persistence in carrying out the development through all its setbacks, the enthusiasm needed to convince others during many years of lean fortune, and a lively imagination.

Dr. Moss's paper shows clearly that the very fact of working intensively toward a major objective provides the setting in which new ideas are evolved. As the development progresses, the problems and obstacles are more sharply defined. The urge toward accomplishment provides a stimulus to ingenuity. The urgency which accompanies any large commitment of man power and money, in peace or in war, calls forth the intensity of mental concentration required for constructive thinking. As the work progresses from general objective to finished product, difficulties continue to arise. Accordingly, the challenge to creative thinking continues from start to finish of the job.

There comes a stage in every development for commercial use when decisions must be reached and designs crystallized. But this does not limit the thinking of the creative engineer. He will have to divide his thinking, concentrating largely on the specific completion of his design. Having by now the complete "feel of the job," and the background of all of his analyses and experiments to date, he will continue to evolve ideas and improvements. A busy man may do his best creative work under pressure. These ideas are simply stored up for use on the next design, since the pace of modern industrial development will call for further improvement soon enough.

Management can do much to stimulate invention, and the promotion of creative work is receiving increasing attention. Individual invention is of course unpredictable, and it is often said that "you cannot schedule invention." Statistically, however, invention can be forecast with reasonable assurance. To work on related projects a group of men with initiative, imagination, and with the habit of logical reasoning can be selected. It is well to have in such a group diverse characteristics and backgrounds of experience (2), so that individual abilities and interests will be complementary, and each can learn something from and stimulate the others. Time, facilities and many personal contacts will be needed to appraise the merits as well as the shortcomings of present practice and to grasp thoroughly the importance of the further objectives. With such a group under wise and encouraging leadership, new ways and means presently begin to sprout. Thus management, by establishing favorable leadership as a stimulus and by combining various points of view in a well-balanced organization, can effectively set the stage for creative work. It can also select the fields in which this sort of progress is most needed to advance the over-all enterprise.

ENCOURAGING CREATIVE EFFORT

It has been observed that young engineers sometimes are reluctant to advance their new ideas, apprehending that the idea may not be new to others or may be received coldly if it does suggest a change from existing practice. It is most important to recognize that invention is involved in conceiving an idea original to the individual, even though it may not be new to the art. Every engineer finds that "Kilroy was here" ahead of him on some supposedly new inventions, and this probability is greatest among young engineers of limited experience. Therefore the ideas of a young engineer should be encouraged, whether patentable or not, provided they indicate sound analysis and original thinking, since these first attempts may well be the forerunners of more valuable contributions with increased experience and perspective. Not only in industry but also during the college course ingenuity should be sought out and rewarded, since this is a talent which thrives on accomplishment and can also be discouraged by indifference.

Encouragement of initial efforts is important also toward avoiding the feeling that "the boss will do all the thinking." At various engineering colleges the author has encountered many able upper-class students to whom engineering development signified little beyond drafting. These young engineers have not yet realized the challenge involved in the creation of new and improved products and systems of equipment, and must have assumed that their opportunity would be limited by some experienced master mind who would do all the forward-looking work. The incidence of real creative ability is rare enough that industry cannot afford to lose men of this talent from the field of engineering development. Such ability is needed and, when developed, can justify a prominent and satisfying career.

The quest for new and superior products, accelerated by the war, continues today with a greater diversity of objectives than ever before. Close co-operation will be needed between industry and the universities so that creative talent may be recognized and developed early in the career of the young engineer, and reinforced with training which will direct this talent toward most effective use.

STIMULATION FROM OTHER FIELDS

Where complex products and systems are involved, many inventions serve as new building blocks added to the existing structure. The filling of these gaps in the technology of one field often produces unexpected results in another, not only by direct transference of ideas but because the imaginative reader sees new applications or is inspired to new ideas in his own field. To many engineers it is stimulating simply to review the account of advances in other lines, the conflict of competitive processes toward a major objective, and the end results achieved by others.

For example, the conversion of coal to gaseous or liquid hydrocarbons which began years ago with the hydrogenation process of Bergius now faces possible far-reaching advances which may indicate a progressive shift from solid to liquid fuel (3). Coal being a basic commodity, it is reasonable to expect that developments in this field would give rise to developments in power and process equipment. Many engineers not directly engaged will follow such developments with interest and will be pondering the implications of such a trend, as it might relate to their own work.

This suggests that the engineer should not concentrate his energies to the extreme of becoming too narrowly specialized. A reasonable proportion of his reading, observation, and study devoted to other industries will repay the effort not only in factual information but in creating a broader perspective from which to view his own work. Often some small by-product of an investigation, if noted by an inquiring mind, becomes the catalyst to launch new progress in another direction.

QUALIFICATIONS WHICH SUPPORT CREATIVE ENGINEERING

Much has been written about the personal qualifications for creative work in engineering. The author prefers to think of invention simply as one of the activities of a well-rounded engineer, although there are many good engineers whose talents do not include inventiveness. As already indicated, this activity

(*Continued on page 665*)

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

THE ALUMINUM CARTELS[1]

By ROBERT L. BISHOP

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A CARTEL is an association of otherwise independent companies in the same line of business, formed for the purpose of limiting or eliminating competition among the members. The techniques of restricting competition vary, but the most usual ones include agreements as to prices, output, sales quotas, and the division of markets.

Such agreements are illegal in the United States under our antitrust laws, with some possible exceptions related to patent licensing. In most of the other countries of the world, on the other hand, contractual cartel agreements are not only legal but often encouraged by the state and sometimes even backed by governmental compulsion.

Cartels, and international cartels in particular, have been accorded a good deal of attention in this country in recent years. The most vigorous investigators of cartel practices have been certain of our legislators and antitrust officials. According to the oversimplified theories of some of these gentlemen, international cartels were primarily to blame for the economic ills of the thirties, for most of our wartime shortages, and even for the war itself. In their extreme form these views are heavily discounted in more cautious circles; but most American students of the problem, for less sensational reasons, deeply disapprove of the cartel philosophy just the same. Our business spokesmen, N.A.M. and C.E.D. alike, also join in these expressions of disapproval of the cartel form of business organization—even though many of our businessmen, by their actions, still betray a good deal of sympathy for the aims and techniques of cartels.

The cartel question is a live one right now, not so much because of the prospect of any major change in our domestic policy toward them, but because of the desirability of working out a more or less mutually consistent set of policies among the nations of the world toward the role of cartels in international trade. This is one of the major questions on the agenda for the proposed International Trade Organization, for which preliminary meetings have been taking place recently in Geneva. There is no prospect that international cartels will be prohibited altogether, because of the support which they enjoy in other countries; but so far the American program for at least "curbing" cartels has made rather surprising headway toward general acceptance.

In this setting the recent small volume[2] by Louis Marlio on the aluminum cartel has a timely interest. Dr. Marlio was for twenty years a top executive of the French Aluminum Company, and from 1926 to 1939 he was chairman of the international aluminum cartel. He gave up all his business connections in 1940, and since then he has been a member of the staff of the Brookings Institution in Washington.

The purpose of his present book is to set forth, first, a factual description of the various aluminum cartels and their policies from 1901 to 1939. Second, he essays an evaluation of the economic effects of these successive cartels. The tone of his discussion is dignified and urbane. Yet, despite his striving for objectivity, there is no mistaking his partisanship. As he sees it, the first cartel made a major mistake in 1907 by setting prices too high, with the result that new competitors flocked into the industry to plague the existing producers; but otherwise Marlio feels that the aluminum cartels were very well conducted to promote the best interests of producers, consumers, and the public as a whole.

It so happens that a scholarly American study of the very same subject matter has also appeared within the last year. This is the chapter of some sixty-five pages called "The Aluminum Alliance" in the volume, "Cartels in Action," written by George Stocking and Myron Watkins under the aegis of the Twentieth Century Fund.[3] The similarities and contrasts between these two competent studies are most instructive. In terms of the objective facts recounted, there are remarkably few discrepancies between them, and all of these are minor in character. As for the range of facts covered, there are important differences. In part this is attributable to the naturally greater interest which the American writers take in the role of the Aluminum Company of America (Alcoa) in the world aluminum industry and in the effects of the European cartel on the American market; but the differences also go deeper and reflect strongly contrasting prepossessions as to the kinds of facts relevant for the evaluation of cartel practices. In turn, these contrasts lead to—or spring from—sharp differences of opinion—or bias—as to the nature and consequences of the aluminum cartels.

Stocking and Watkins, it seems to me, give by far the more complete story; but that may simply indicate that my own bias is nearer theirs than Marlio's. In any case, the individual who wants to get both sides of the story should certainly read the two accounts; and, regardless of the side which he may finally take, he will certainly be edified by the contrasting interpretations which he finds placed on essentially the same history.

In his introduction to Dr. Marlio's book, Harold Moulton, who is the president of the Brookings Institution, says: "This authoritative report should serve as a corrective to numerous misstatements and misinterpretations of aluminum-cartel policy by authors not in a position to know the facts." This would seem to indicate that Marlio was about to present essentially new facts, hitherto unavailable. This, unfortunately, is not so. A careful reading of the two books shows that there is very little to be added or corrected in the account of Stocking and Watkins in the light of that by Marlio. Indeed, Marlio has rather scrupulously confined his facts to those which were either generally available all along or made public as the result of American investigations, including notably the antitrust suit against Alcoa. Thus, when he comments on the cartel's effects on profits, Marlio says (pp. 79–80): "Unfortunately, it is not possible for me to indicate the precise effects of this policy upon profits, inasmuch as the profits were made by producing companies in various countries, some of which have never made public the details of their financial operations." In other words, here as elsewhere in his book, Marlio makes clear that he is not "telling all." He does give us his conclusion (p. 81) "that the profits made by the aluminum producers during the

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "The Aluminum Cartel," by Louis Marlio, The Brookings Institution, Washington, D. C., 1947, 130 pp., $1.50.

[3] "Cartels in Action: Case Studies in International Business Diplomacy," by George W. Stocking and Myron W. Watkins, The Twentieth Century Fund, New York, N. Y., 1946, 533 pp., $4.

period 1926–1939 were on the whole satisfactory. Certainly the financial position of all the producing companies was good at the end of the period." But this hardly advances any student's knowledge of aluminum profits. Rather, the admittedly incomplete data compiled and estimated by independent scholars are still the best that we have; and these studies would indicate that Marlio's characterization of profits errs, if at all, on the side of a modesty appropriate to an insider defending the aluminum cartel.

As to Marlio's correcting "misinterpretations of cartel policy," since his own interpretations are not based on different objective evidence, other capable scholars who have drawn conclusions less flattering to the cartel from the same evidence are not likely to be impressed by his apologia. Marlio's defense of cartel policy in terms of "stabilization," "avoiding cutthroat competition," and "promoting long-term price reduction and market expansion" is nothing new; these are all too familiar as cartel clichés and claims.

Stabilization, for example, concerns prices—and, to a lesser degree, profits—rather than output and employment. Of course, cartel executives share with everyone else the desire to stabilize all these magnitudes; but since, under conditions of shifting demand, price stabilization inevitably places all the burden of fluctuation on output—and vice versa—we can never have the best of all possible policies. Marlio knows this, of course; and when he gets down to brass tacks he is frank enough to describe faithfully just how the cartel administered the variations of output that were needed to maintain satisfactory prices. In 1932 and 1933, for example, output was set for each and every cartel member at fifty per cent of a somewhat artificial figure for capacity, so that the companies could make profits that were "on the whole satisfactory." Likewise Marlio makes no bones about the cartel's having served to restrict output as compared with what the companies would otherwise have produced. Before the cartel's control was tightened in 1931 the members were producing for inventory in the face of the depression demand. Now this *is* one way to help stabilize output over the business cycle; but to Marlio it was a triumph of the cartel to have put a stop to this policy. Not only were further additions to inventories avoided, but the stocks already accumulated were successfully reduced throughout the period of deepest depression. Naturally, this meant that output fell all the farther during these years.

With respect to avoiding cutthroat competition, many economists concede some justification to restraints that serve to avoid really severe business losses—even though others, thinking that bankruptcy and recapitalization are lesser evils than curtailment of output and employment, frankly oppose all restrictionist measures which take the "loss" out of a profit-and-loss system. But the primary issue here is whether the aluminum industry needs cartelization to avoid the kind of losses which might be so demoralizing as to harm the public interest. Stocking and Watkins think not. After identifying one type of cartel as "purely defensive" they go on to say (p. 7): "At the other extreme is aluminum, which has never in its half-century history known ruinous prices or faced a serious problem of excess capacity or dislocated markets. The successive aluminum cartels, from 1896 to the present, were not the product of economic distress. They were not defensive measures to protect an overexpanded industry from the 'ravages' of economic readjustment. They have been instruments of economic agression. The financial record of aluminum companies, through good times and bad, at home and abroad, attests the efficacy of cartel controls to insure a high rate of earnings." Even Marlio does not argue that disaster might have overtaken the industry as a whole in the absence of the cartel agreements, but only that certain producers would have suffered losses. To support his view that high-cost producers were given no undue consideration in the formulation of cartel policy, he says (p. 111): "The low-cost producers could continue to operate with profit without making any agreement with the high-cost producers; the contrary was not true." Besides being a curious rebuttal to the charge that the high-cost producers were "protected," this remark would seem to concede the broader point made by Stocking and Watkins.

In Marlio's opinion, the cartels in recent years have followed a "low-price policy." By this he means only that prices were not set so high in prosperous years as to invite the entry of new producers, as in 1907. Such self-restraint, of course, is only enlightened self-interest, and as such quite commendable. Whether it provides an adequate safeguard to the interest of consumers, however, is another question—especially in an industry which is so notoriously difficult to enter because of unusual requirements as to capital, electric power, and access to closely held raw materials. As to the relative efficacy of potential and actual competition in bringing down aluminum prices, recent American experience is revealing. By contrast with the situation in Europe, prices came down in this country during the 1930's, despite the fact that Alcoa was still our sole domestic producer. Since 1940, however, Alcoa has had some actual competition. Recently the company which started production in 1940 has been advertising aluminum prices thirty per cent below those of 1939, despite our generally higher price and wage-rate levels.

Marlio also does his best to justify the cartel's failure to set lower prices, especially in time of depression, by a whole series of familiar arguments that point to a slight responsiveness of consumption to price reductions. Even if true, such an "inelasticity" of demand does not set aside the public's interest in lower prices; but, even from the producer's point of view, Marlio's argument is incomplete. He fails to mention at all the substitution of aluminum for other materials in response to price reduction, but stresses simply the fact that (p. 63) "the metal is ordinarily used along with other products and commonly constitutes but a small fraction of the total cost of the finished article. For example, there are only about 15 pounds of aluminum in the ordinary automobile." To evaluate this typical instance of unimaginativeness on the part of the monopolist, one need only read one of the many informative footnotes in the chapter by Stocking and Watkins (p. 218, n.): "At one time the average consumption per car by Buick reached 240 pounds; by Hudson, 180 pounds; and by Studebaker, 110 pounds. But the persistent adherence to a high-price policy by Aluminum Company of America, coupled with the reluctance of the automobile manufacturers to become dependent on a single source of supply for a vital construction material, cut off much of the potential market in this field. The peak automotive consumption per car was reached about 1914, when aluminum was selling under 20 cents a pound for the first time, though there was a temporary upsurge in the early twenties during another dip in price."

On the constructive side, Marlio cites efforts of the cartel to expand markets by centralized promotion and publicity and by co-operative technical research. These measures seem not to have been of impressive magnitude, however; and in any case they can be separated from the restrictionist activities of cartels, as some American trade associations and other co-operative arrangements illustrate.

On the subject of the relationships between Alcoa and the European cartel, Marlio has only a few comments. He emphasizes, as is perfectly correct, that Alcoa was not a member of the cartel formed in 1926 and revised in 1931, and that the Aluminium Company, Ltd. of Canada (Alted), which did join the cartel in 1931, is not a subsidiary of Alcoa. Alted was cre-

ated in 1928—and not before the establishment of the 1926 cartel, as Marlio implies (p. 21)—to hold all of Alcoa's foreign properties. Since Alted's shares were then distributed pro rata to Alcoa's stockholders, the two companies became legally independent entities, even though the same three families retained majority control of both corporations. This freed Alted to join the European cartel, outside the jurisdiction of the United States' antitrust laws. Citing these facts, Marlio adds only the legalistic observations (pp. 30–31) that "officials of Alcoa did not participate in the negotiations between the European groups and the Aluminium Company, Ltd. None of the agreements contained restrictions of any sort pertaining to sales to or exports from the United States. Nor were there any secret understandings between Alcoa and the Alliance with respect to markets or otherwise."

Let the reader, however, beware. Before he concludes that Dr. Marlio has revealed all that might be relevant on this subject, he should at least read the analysis of Stocking and Watkins (especially pp. 260–261 and 265–266). And he might also read the company memoranda which they quote (p. 249, n.), describing specific agreements on exports to the United States in 1927 between the Americans and certain of the principal cartel members, though not with the cartel itself.

As to the relationship between cartel policies and European sales of aluminum in the United States, Dr. Marlio indulges in some carefully selected statistical evidence. After giving a table that shows the percentage relationship of cartel sales in the United States to Alcoa's sales from 1931 to 1937 (p. 43), he observes that "after 1932, the percentage sold by the cartel was much higher than in the four years prior to the establishment of the Alliance Company [in 1931]." This is correct, but it hardly meets the point made by Stocking and Watkins that Alcoa began to enjoy protection from European competition, not when Alted joined the cartel, in 1931, but when the cartel was formed toward the end of 1926. From a computation which I have made from data in Stocking and Watkins—who provide, incidentally, a far richer source of general statistical data than does Marlio—the following facts appear. From 1920 through 1926, when there was no cartel, American imports from Europe were 28 per cent of Alcoa's production; from 1927 through 1931 they were 8 per cent; and from 1932 through 1937 they were 13 per cent.

I might add that this is only one of several instances of selective reporting on the part of Dr. Marlio. I am satisfied, in so far as his facts are concerned, that he tells the truth and nothing but the truth. Most certainly he does not tell what the interested student would consider "the whole truth."

Invention in Engineering Development

(*Continued from page 662*)

does not stand alone but may be carried on in combination with the engineer's other work and is stimulated by the needs which he encounters.

As a foundation for useful inventions an engineer needs good business and economic judgment, so that his activities will be aimed toward worth-while results. Supervision can assist by defining proper objectives, but cannot relieve the engineer of the obligation of pointing his work and his ideas directly toward a useful outcome. Dr. Kennelly has related (4) that Edison never attempted creative work until he knew thoroughly the existing state of the art through observation, inquiry, and reading. Combined vision and business perspective enabled him to select his objectives shrewdly, but if a project proved impracticable or seemed to have no useful end result, he saved his energies for more worth-while projects. Since the value of most new ideas is not surely established until they have been elaborated and weighed through some embodiment, the combination of business judgment and vision is most important; judgment to sort out the poor risks, vision and imagination to avoid condemning a new thought too easily.

Ability in logical analysis is fundamental in creative work. It is well established that a thorough training in mathematics, physics, and basic engineering fields helps to develop the habit of logical analysis which is vital to an engineer in every phase of his work. Where one finds a good technical man, one is more than likely to find an analyst, although the quality of inventiveness may or may not be present.

Many inventions and discoveries have been practically rationalized into existence. New knowledge often comes as an almost inevitable result of logical analysis, since the analysis points up the need and the boundary conditions clearly, and indicates the gaps which imagination must fill. The astronomer calculates from known measurements where an unknown mass must be, and there it is observed as telescopes become powerful enough to find it. Mendelejeff's periodic table of the elements postulated certain substances before they were identified in Nature. Again, during the recent war, sudden and urgent demands for new means of measurement and location followed in quick succession. Starting with discussions to clarify the exact requirements, and proceeding through analysis of possible circuits and their responses, it was often difficult to say where analysis was complete and invention began.

However, economic sense and analytical reasoning are not offered as substitutes for imaginative thinking, since they alone may not disclose the missing links which true invention supplies (5). They do provide an excellent point of vantage from which to judge existing accomplishments and foresee the direction in which creative thinking should point. Thus an engineer who is endowed with the ability to create new results and who can also guide his course with sound technical and economic analysis will arrive most effectively and speedily at objectives valued by industry.

SUMMARY

1 Invention and creative effort extend beyond the conception of an idea; their value grows with development and with the accretion of further new thinking.

2 Invention in engineering is stimulated by concentration on active development work toward a recognized general objective.

3 By proper grouping of abilities, management can create an atmosphere favorable to invention.

4 It is important to identify creative talent early, and to encourage initial efforts even though not patentable.

5 Invention can be spurred by the study of significant advances in other fields.

6 The habit of logical technical and economic analysis is not a substitute for inventive thought, but a powerful aid in directing invention to most effective channels.

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BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

COMPILED AND EDITED BY J. J JAKLITSCH, JR.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Shortage of Engineers

AT the 54th annual meeting of the Society for the Promotion of Engineering Education (now the American Society for Engineering Education) in June, 1946, a committee of the Society under the chairmanship of Dr. K. T. Compton, member A.S.M.E., president, Massachusetts Institute of Technology, presented a report entitled "The Outlook in the Demand for and Supply of Engineering Graduates." This report, known as the Compton Report, represented a sincere effort to estimate the future demand for and supply of engineering graduates in the United States, as an aid to the engineering colleges in their planning for the future. The report appeared in the *Journal of Engineering Education* in September, 1946.

Briefly, the Compton Report indicated that 337,000 engineers will be needed in the United States by 1950, a net increase of 76,000, or 29.1 per cent over the 261,000 available in 1940 (including about 16,000 unemployed). Since 78,000 are expected to retire, leave the profession, or die, between 1940 and 1950, a total of about 154,000 new engineers will be needed.

From 1941 to 1946, 64,000 degrees were granted, leaving a need for 90,000 in the four remaining years from 1946 to 1950, or about 23,000 new engineers per year. Thus the average of 10,700 engineering graduates annually in the first six years of this decade must now be more than doubled in order to catch up with our demand by 1950.

A survey among the personnel directors of 125 companies showed that in the ten years from 1938 to 1948, the number of engineering graduates required will be nearly tripled in the fields of research and development and doubled in production, sales, and management. Not only are the companies increasing the rates of research engineers to total engineers, but in the research field they indicate a need for a higher percentage of engineers holding advanced degrees.

The committee's estimated annual need is about 9.4 per cent of the number of engineers employed in 1940. The industrial questionnaires indicated an estimated need for annual increases of about 17 per cent of present employment. The difference between these estimates is partially accounted for by the fact that in an individual company there is a fourth kind of attrition which does not enter into the national picture—that of men transferring from one company to another.

The committee listed several reasons for believing that this estimated need of 23,000 engineers per year for the next four years might be too low, and pointed out that the 23,000 per year is a short-term requirement. After full employment is achieved the annual need for engineers will be only the number needed to care for the small increase in population, plus the number made necessary by further increases in the ratios of engineers to total employment, plus replacements. This need was estimated at about 18,000 per year, which is 50 per cent above the number the engineering colleges were graduating prior to the war.

In its study of the prospective supply of engineering graduates to meet these needs, the committee estimated the maximum capacity of engineering schools in the United States to be 155,000, or 37 per cent above the previous maximum enrollment of 113,500 in 1942–1943. It was assumed that the number of first degrees granted would continue to be 53.8 per cent of the number of registered freshmen four years earlier as it was prior to 1941, and that the corresponding ratios for sophomores and juniors would continue to be 64.7 per cent and 71.8 per cent, respectively. It was also assumed that the freshmen enrollment in engineering would bear the same proportionate relation to total undergraduate enrollment which obtained in 1941, namely, 36½ per cent, which would mean freshmen classes for 1946 and 1947 of 56,500, on the basis of a total enrollment of 155,000. Certain assumptions were made as to the proportion of veterans and nonveterans who would follow accelerated curricula.

Based on these assumptions and on the estimate that the current deficit in engineering graduates was 8000, the committee worked out a tabulation showing the expected numbers of first degrees to be granted during each year up to and including 1952. Starting with the deficit of 8000 and adding the 23,000 estimated as needed in 1946 gave a total demand for 1946 of 31,000, which could be only partially filled by the 7000 first degrees to be granted in 1946, from which must be subtracted 1500 whom it was assumed would enter graduate schools. This left a net deficit for 1946 of 25,500. Continuing by this process the committee arrived at the conclusion that the deficit of graduate engineers would be filled by 1952, and pointed out that "this means that the need for continuing engineering education at an overload level will lessen beginning with the entering freshman class in 1949."

A re-examination of the Compton Report made by Henry H. Armsby, specialist in engineering education, U. S. Office of Education, and appearing in the May, 1947, issue of the *Journal of Engineering Education*, points out that when the Compton Report was presented few responsible persons in the field of education foresaw the tremendous numbers of veterans who would seek college admission in the fall of 1945. The estimates of the committee as to the prospective supply of engineers were based on what the engineering schools had stated to be their maximum capacity of 155,000 students, including 56,500 engineering freshmen. Actual enrollment this fall is about 223,000, including about 92,600 freshmen. These are estimates based on data reported to the secretary of A.S.E.E. by the institutions which, up to Dec. 1, 1946, had submitted complete reports differentiating veterans from nonveterans.

Enrollment figures in all colleges and in engineering colleges for November, 1945, and November, 1946, taken from a report of the Research and Statistical Service of the U. S. Office of Education, indicate college and university enrollment has more than doubled since last year. The enrollment of men is nearly four times that of last year, and of veterans, 20 times that of last year, while the ratio of veterans to all men has increased from

14 per cent to 77 per cent. Also, the enrollment as reported by 90 engineering schools has increased at a greater rate than that for all colleges and universities, and that the men enrolled in engineering have increased faster than the men in all colleges. Figures show that the percentage of engineering students to all college students has increased since last year from 6½ per cent to 10.6 per cent.

In the Compton Report it was indicated that the shortage of engineers in this country would be met by 1952. The estimates in the re-examination indicate a surplus of engineers in the United States in 1949. Actually, the oversupply may well become evident in 1948. In either event, it seems evident that the engineering colleges are facing some serious problems—not in 1949, but now.

Before discussing the problems arising from the present enrollment in engineering colleges, it may be well to discuss some of the many possible errors in the estimates contained in this discussion, which might easily change the small deficit estimated for 1948 into a surplus.

1 Only 147 schools were considered in deriving the factor 1.9 by which the enrollments in 90 schools were multiplied to obtain the estimates of total enrollments in engineering schools. However, very few large schools are omitted from this group, and therefore this error should be very small, and is probably offset by a small error in the S.P.E.E. figures for 1940. (The factor 1.9 is the ratio of the estimated national total of 223,000 to the 117,300 reported by the 90 institutions.)

2 The number of degrees granted in 1946 was estimated by the Compton Committee at 7000. The number reported by the 90 schools used in this study is 4500. If this be multiplied by the factor 1.9, the result is 8600, an increase of 1600 over the committee's estimate.

3 The estimated shortage of 8000 engineers in 1946 should not have been used, since it was automatically included in the estimate of 90,000 engineers needed by 1950.

4 The survival ratios used in the Compton Report may well be too low. If so, the number of graduates will be larger than is indicated.

5 In the estimate of the demand for engineers in this country there are also many chances for errors, some of which are pointed out in the Compton Report.

In the original study it was estimated that after the attainment of "full employment" in 1950 the number of engineers needed merely to keep up with the growth in population and to provide for replacements in the profession would be from 10,000 to 12,000 per year, or approximately the number of engineers who were being graduated from engineering colleges before the war. The sharp increase in emphasis on research and development evidenced by the returns to the industrial questionnaire was mentioned. This also is evidenced by the competition for top-flight scientists and engineers by government agencies, such as the Army, the Navy, the Joint Army-Navy Research Board, the Public Health Service, the National Bureau of Standards, the Veterans' Administration, and others.

This sharp increase in emphasis on research and development is an extremely significant factor in any determination of future needs for engineers, since it obviously points to greatly increased needs for thoroughly trained engineers and scientists. Some production jobs may perhaps be filled by mediocre engineering graduates or by competent graduates of technical institutes, but the research and development positions certainly will require a higher type of engineer and scientist.

All of these general trends lead to the belief that the Compton Committee's estimates of demand for engineers in this country are more likely to be too small than too large.

In any event, it is evident that there are serious problems facing the engineering colleges now. A few of these problems are:

The need for a program which can produce men and women who can intelligently use the scientific method in attacking social and political problems, and can appreciate and take into account the social and political aspects of engineering and scientific problems, in short, men and women who can be "engineering statesmen."

What kind of guidance should be given veterans and others as to their future occupations, and by whom? A grave responsibility rests on the engineering colleges, in view of the tremendous number of present and prospective students, both qualified and unqualified, seeking to be engineers, and because of the great need of industry for really competent engineers and scientists.

The shortage of technical-institute graduates, coupled with the indicated surplus of graduate engineers, may mean that many graduate engineers will find themselves assigned to work which could be done satisfactorily by technical-institute graduates. Does this call for a revision of engineering curricula and of the general administration of engineering colleges? Is it possible that society would be better served if provision were made for a certificate of proficiency at the end of two years for those who have not demonstrated their ability and their aptitude for professional engineering work?

Does the pronounced shift toward research in government and industry mean that the engineering colleges should increase their efforts to persuade their best students to continue with graduate work, for their own good and for the good of the country?

What kind of teachers do the engineering colleges need and how can they be recruited? Can programs be developed to train engineers to teach? Can industry and education work out some sort of co-operative system for teachers as they have done so successfully for students?

What sort of relations should there be between higher education and the Federal Government? Should there be a program of Federal aid to education?

Should we modify our present curricula, or perhaps set up new curricula, in order to give students a good general fundamental training in the basic physical sciences and a general understanding of engineering and scientific procedures?

Nuclear Photography

SPECIAL photographic plates made in the laboratories of Eastman Kodak Company, Rochester, N. Y., are being used by scientists to picture actual atomic fission and to study action of highly charged nuclear particles, it was announced recently.

The plates are known as "nuclear track" plates from their special use in recording the paths of the particles.

Characteristics of the new plates are markedly different from those of ordinary photographic materials. The plates are supersensitive to the electric charges carried by atomic particles. At the same time they are relatively insensitive to light—which affects ordinary film—and to x rays.

The silver grains in the emulsions of the nuclear-track plates are unusually close-packed. It is these silver grains, suspended in the gelatine emulsion, that are particularly sensitive to the charged nuclear particles.

When a highly charged particle speeds into the emulsion, a dotted line of affected silver grains is produced. These silver grains, when the plate is developed, make an identifiable track. This is the path of the nuclear particle through the emulsion.

From the length and curvature of the track and the grain-spacing along it, information is obtained of the particle's

speed, energy, and other characteristics. Thus the particle can be identified as a proton, alpha particle, or heavily charged nucleus.

It is reported that actual fission was recorded when one of the plates, first bathed in uranium nitrate, was exposed to slow neutrons from a radium-beryllium source. A neutron, striking a uranium atom in the emulsion, brought about the fission which was recorded on the plate as the track of two new atoms.

The company pointed out that the new plates are designed to record tracks of individual nuclear particles rather than to record density because of over-all exposure to radioactivity.

For this reason the especially fine-grained emulsions not only give the characteristic track of a nuclear particle but also make little record of the "background" radioactivity. Thus the nuclear track itself stands out clearly in the emulsion.

Special advantages of the nuclear-track plates are that they are continuously sensitive and can record permanently isolated acts of particles over a period of time. They also provide for recording of a great deal of scientific data with simple inexpensive apparatus.

Radiant Heating

TEN years ago radiant heating in the United States was a method of space heating mentioned briefly in scientific books. There were only four recorded installations in the country. No practical information on the subject was available. Today there are upward of 10,000 installations and nearly a thousand new ones are being made each month, according to A. M. Byers Company, Pittsburgh, Pa., which has compiled technical information on individual installations since 1937.

The approximate number of radiant-heating systems now in use throughout the country is based on a nation-wide field survey made among architects, pipe suppliers, heating contractors, and engineers, and an analysis of the sales records of wrought-iron radiant-heating pipe.

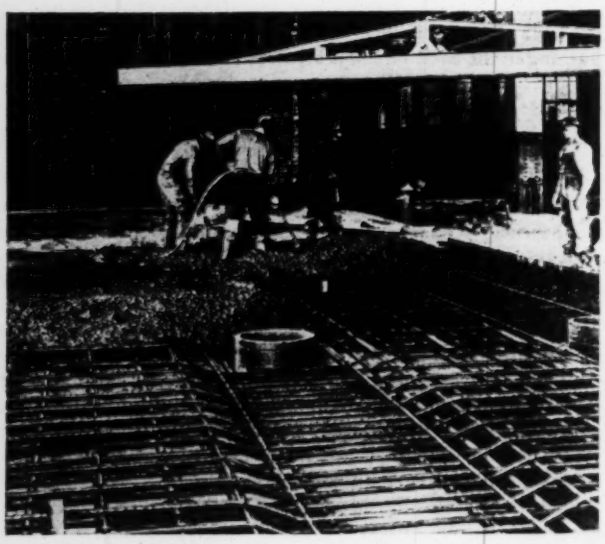


FIG. 1 WORLD'S LARGEST RADIANT-HEATING INSTALLATION

(Ten inches of concrete is poured to make a reinforced slab over radiant-heating pipes which will maintain a comfortable temperature in the quarter-mile-long warehouse being built by United States Steel's pipe-making subsidiary, National Tube Company, Lorain, Ohio. A total of 25 miles of 1-in. steel pipe, grouped in 481 coils, are embraced in the closed 3-acre system, which will heat more than 7 million cu ft of air. The coils are connected in groups, with automatically controlled valves governing the flow of water from four heat exchangers.)

As important as the rapid increase in the number of installations is the fact that radiant heating has been used in virtually every type of structure, both private and government-owned, in every part of the country. These include homes in all price ranges, and commercial, industrial, and institutional buildings.

A cross-sectional survey of 1000 typical installations located in 45 states reveals that Ohio has 16 per cent of the projects surveyed; Pennsylvania has 11 per cent; Illinois, 6 per cent; and New York and Massachusetts, 5 per cent each. Every Southern state is represented among these projects, Virginia leading with nearly 5 per cent of the national total.

The analysis shows that 93 per cent of the installations surveyed use floor-type radiant heating coils. There were no projects in which wall coils exclusively carried the heating load but a few installations had wall panels as supplementary heating elements. In a number of buildings, both floor coils and ceiling coils were used. These were principally multiple-storied structures where floor coils were used in the first floor and ceiling coils in the other stories.

More than 90 per cent of the installations surveyed have the radiant-heating coils in concrete floors. Finish floor coverings used include hardwood flooring, linoleum, asphalt and rubber tile, mosaic, marble and quarry tile, terrazzo, various cement mixtures, and rugs and carpeting.

More than 95 per cent of the radiant-heating pipe coils in the installations surveyed were welded. Improvements made in welding techniques and an increase in the number of qualified welders, trained during war years, have led to the almost exclusive adoption of welded coils.

Seventy-three per cent of radiant-heated buildings included in the survey are one-floor plans, 25 per cent are two-story structures, one-plus per cent three-story buildings, and less than one per cent for those above three stories.

One reason the percentage of radiant-heating systems installed in one-floor structures is high, is the fact that government restrictions limited the number of multistory buildings that were erected during the war.

The floor-heating method has eliminated many of the problems inherent to basementless construction, such as dampness and cold drafts. Therefore it was accepted more rapidly for such structures as garages, aircraft hangars, factories, and one-story houses which have floor slabs built on grade. That the system is just as practical for multistory buildings has been proved by installations in buildings up to eight stories high.

Many of the radiant-heating systems studied utilize both sinuous coils and grids. The available data (incomplete for many structures) reveals that 55 per cent of the installations contain sinuous coils and 45 per cent grid coils. Common practice, the survey indicated, seems to be to specify grid patterns for large areas and sinuous coils for small rooms. Factories and garages, for example, frequently have grid designs in the shop areas and sinuous coils in offices and rest rooms.

X-Ray Protection Program

SCIENTISTS at the National Bureau of Standards are engaged in an extensive program for determining the effectiveness of concrete as a protective barrier against million-volt wide-beam x rays, whose use is increasing in medicine and industry. At the present time, exact wall thicknesses and most desirable types of construction necessary for maximum short-wave-length x-ray protection are not definitely known. One of the basic aims of the new project is to collect data from which the highest degree of protection with the lowest possible cost

of installation can be calculated. Broad-beam x rays, allowing simultaneous examination of wide areas, have come into extensive use. While broad-beam x rays, ranging in diameter up to 4 or 5 ft, are not essentially different (except for the amount of surface covered) from narrower-beam radiation, they pose a special protection problem.

When a broad x-ray beam enters a thick concrete wall, it is scattered and rescattered many times with the result that a considerable fraction of the beam emerges on the other side, endangering personnel. Quantitative information on the amount of this scattering is not yet available.

To determine protection standards, a 1½-million-volt x-ray machine in the Bureau's laboratories has been converted so that it will produce beams of varying widths. It is mounted so that it can be directed downward into a "radiation pit" about 6 ft square and 20 ft below the target of the x-ray tube. Special instruments, designed to explore the strength of the radiation in the pit, can be shifted to various positions by remote control. Both the control and the x-ray reading equipment are operated from a central control room surrounded by 18 in. of concrete and located 75 ft from the radiation pit.

During the investigations, test slabs of concrete each weighing 2½ tons and measuring 6 in. in thickness are used. These slabs, when placed over the mouth of the pit one at a time, enable investigators to vary the protective barrier from 6 in. to 5 ft in thickness. Since space and weight are of critical importance in many installations, arrangements have also been made for producing "sandwiches" of lead and concrete in alternate layers. At present, the best proportion between these two materials is entirely unknown.

With the advent of the betatron operating at from 50 million to 300 million volts, scientists are confronted with a new series of x-ray problems. While protection from the direct beam of x rays at 50 million volts is very important, there are other simplifying factors in the problem. For example, as science goes to higher and higher voltages in the production of x rays, the x rays themselves tend more and more to merge in a single direction from the target. Thus the x-ray beam emerging from a 50-million-volt betatron covers the very small angle of only 6 or 8 deg. For this beam alone, very great thicknesses of concrete may be required. On the other hand, x rays which are scattered sideways out of this beam are of very much less penetrating character, and as a consequence it may be found that the protection problem to the side of the beam may not be seriously different from that at 1 or 2 million volts.

These problems, however, are all uncertain at the present time and it is the responsibility of the Bureau to set up the necessary experimental arrangements to properly evaluate them. Again, a solution must be found which is safe and yet provides the maximum economy, since the cost of protection alone in a 50-million-volt medical or industrial installation may represent half to three quarters of the total cost.

Weaving Machine

REVOLUTIONARY principles applied in the Swiss weaving machine, see Fig. 2, are to be incorporated in the five new "shuttleless loom" prototypes being developed by The Warner & Swasey Company who have the American manufacturing rights to this machine. It is one of four in test operation at the company's plant in Cleveland, Ohio, where two years of study led to a decision to redesign the Swiss models in the interest of more economical manufacture and use in this country.

It is expected that the five pilot models will be completed during the last quarter of 1947 and that if tests of these machines are successful, the first production models will reach the market early in 1949.

FIG. 2 SWISS SULZER WEAVING MACHINE

Basic principles of the machine provide for introduction of the woof or filling yarn by means of a gripper which draws the filling thread from a single "cheese" of yarn like that shown in the immediate foreground on the left of Fig. 2. The small steel gripper obviates the necessity for bobbin winding and the use of a shuttle which rides on the yarn in other looms. The gripper never comes in contact with the warp yarns, since it is shot through a series of guides which are introduced between top and bottom sections of the warp when the shed is open.

Lightning Research

LIGHTNING scientists of the General Electric Company will again ascend to the top of the Empire State Building, New York, N. Y., to investigate one of nature's most spectacular secrets, the mystery of lightning.

The company announced recently that its high-voltage engineers, headed by J. H. Hagenguth, will renew their study of lightning's effects on the world's largest skyscraper. It continues a study begun by the company in 1935 under Dr. Karl B. McEachron, one of the nation's foremost lightning experts, and discontinued during the war.

To study the phenomena, which strikes at a speed a million times faster than sound, the company will use sensitive lightning-recording devices in an attempt to record lightning data heretofore unattainable. The study will be limited to instrument recordings at first. However, photographic studies of lightning striking the building, simultaneously timed with oscillographic recordings, will also be renewed when suitable space is found to locate the special lightning cameras.

The Empire State Building was originally chosen for the

studies because the high building is said to attract lightning. The previous studies there, from 1935 to 1941, with both oscillographs and high- and low-speed cameras, resulted in detailed knowledge of the frequency of lightning strokes, its wave shapes, currents, amplitudes, and other scientific data.

The study revealed that lightning strikes the same place more than twice. Records showed that the building was struck 12 times in one storm and on one day nine times in 20 min. The maximum number of strokes to the building in one year was 42.

The cameras revealed that about 80 per cent of the strokes to the building originated at the top of the Empire State Building and were fired into the sky. It is the reverse procedure of the cloud-to-ground stroke familiar to the average person and is "triggered off" when the building absorbs an excess of positive current from the earth.

Another discovery was that not all lightning strokes produce thunder. It was reported that none of the strokes from the building to the sky was followed by thunder. It was also revealed that current persisted as long as $1\frac{1}{2}$ sec in some cases.

Added to the information already obtained, the data sought now will not only add to man's understanding of the lightning phenomena, but will improve his ability to reproduce natural lightning in the laboratories. This is important to the development of improved lightning-protective equipment for the electrical and other industries.

Gas

GAS is becoming an increasingly popular fuel, as well as an important raw material for chemicals, according to the *Industrial Bulletin* of Arthur D. Little, Inc., June, 1947. A survey in early 1946 showed that 52 per cent of new homes would be gas-heated, compared with only 11 per cent of all homes existing in 1940. In Texas, dozens of new chemical plants are, or soon will be, converting natural gas to chemicals for solvents, antifreeze, plastics, rayon, fertilizer, and other products. Two new plants in the Southwest will make gasoline, Diesel fuel, and chemicals from natural gas.

To help supply these needs, new natural gas deposits are being found—last year reserves showed a net increase of 13 trillion cubic feet to a total of 160 trillion, despite withdrawals of 5 trillion—and pipe-line systems are being built to carry the gas thousands of miles from the southwestern fields to population centers. Manufactured gas, usually made from coal or coke near the point of use, is also receiving attention. New methods of production may result in economies; one company in Alabama is experimenting with the conversion of coal to gas underground to avoid the expense of mining and handling solid coal. (See "Underground Gasification," MECHANICAL ENGINEERING, May, 1947, pp. 408 and 409.) The trend is toward less production of gas by the distributing utilities and more purchasing from large central producers. Natural-gas companies are the most important source now, but coal companies may sometime gasify coal at the mine and ship the gas by pipeline to the cities.

Natural gas is already a much more important source of heat than manufactured gas, and projected pipe lines will introduce it to many new consumers. After new compressors are installed, the Big Inch and Little Inch pipe lines will deliver 150 billion cubic feet of natural gas annually to the East. Pipe-line construction projects approved in the first year after the war will add 4500 miles to the 61,000 miles of main gas-transmission lines previously existing, and an annual throughput of 400 billion cubic feet. One of these new lines will run from Texas to Southern California and another to Detroit, Milwaukee, and cities along the route. Transporting gas for 1500 miles through a pipe line such as the Big Inch costs about 21 cents per thousand cubic feet; gas at the well-head costs only about 5 cents, a potent reason for establishing chemical conversion plants in the Southwest. Natural gas has high heating value, about 1000 Btu per cu ft, hence it can be more economically transported than manufactured gas, with a typical heating value between 500 and 600 for the type used domestically. Most natural gas is used industrially, but even so, more natural than manufactured gas is used domestically, since houses are commonly heated with natural gas where it is available.

Underground gasification of coal, suggested several years ago, and already employed in Russia on a commercial scale, does not yet offer a solution to the difficulties of mining. Generally, a U-shaped tunnel is dug into the deposit of coal, with two openings at the outcrop of the seam. A fire is started in the interior of the shaft and air is blown in one of the openings. Incomplete combustion of the coal, as well as expulsion of some volatile materials, produces a gas which is collected at the other opening. The direction of flow is periodically reversed for uniform burning within the mine. The air may be alternated with steam and enriched with oxygen to increase the heating value of the gas.

Several variations of this procedure have been attempted in Russia since 1933, leading to the first commercial installation in 1940. The experiments have been plagued by cave-ins, combustion of the gas in the mine, seepage of gas to the atmosphere, and other difficulties. A particular problem has been formation of large pockets as the coal is consumed. Here the air can mix with the gas and burn it before it can leave the mine. The Lyubertsy Station near Moscow has, however, produced a gas of 124 Btu heating value, using air containing 25 to 30 per cent oxygen. Two other large-scale stations were closed by the war. The Russians report that output per man can be increased from 30 tons per month to the equivalent of 100 to 120 tons per month by underground gasification. In U. S. mines, which are more highly mechanized, a man produces about 120 tons in a month of 6-day weeks and in some the output is more than 300 tons.

An experiment recently completed by the Alabama Power Company and the Bureau of Mines involved the underground gasification of 800 tons of coal in a block 150 ft long × 40 ft wide. When a straight steam run followed a period of air blasting, gas with a heating value as high as 240 Btu per cubic foot was produced. With use of oxygen and steam, the heating value may possibly be stepped up to an estimated 300 Btu per cubic foot.

Because of the low quality of gas produced underground, gasification on the surface is projected for the $300,000 pilot plant of the Standard Oil Company (N. J.) and the Pittsburgh Consolidated Coal Company, Library, Pa. Pulverized coal from near-by mines will be "fluidized" to react with a stream of oxygen and steam to produce "synthesis gas," which may be converted to gasoline and other liquid fuels by the Fischer-Tropsch process. The possible ultimate outcome of this experiment will be a $120 million plant to produce 400 million cubic feet of gas from 20,000 tons of coal daily. In winter, when the demand for gasoline falls off, the synthesis reaction might be modified to produce more gas for domestic heating; in summer, gasoline would be produced at a maximum rate of about 14,000 barrels a day.

Interplanetary Travel

THAT interplanetary travel may well become possible during our lifetime was prophesied recently in a radio broadcast by Dr. Lyman Spitzer, Jr., associate professor of astro-

physics, Yale University, New Haven, Conn. His topic was "The Rocket: A Tool for Exploring the Universe."

He stated that with the present type of rocket it was probably not possible to reach the moon or any other planet, but the enormous amount of atomic power now available in a small amount of uranium or plutonium quite changes the picture.

As yet no one has designed, let alone built, a rocket based on this source of energy. But within several decades it should be possible to construct an atomic rocket which could escape from the earth's gravitational pull without great difficulty.

Exploration of other planets is only one of the two ways in which rockets can be of great help to science. The second way is to use a rocket as a platform for making scientific observations that could not be made at the earth's surface.

This second way does not require the super rockets of tomorrow, since the 100-mile ascent of the V-2 rocket is high enough for most purposes. Practically every V-2 launched in New Mexico carries many hundred pounds of automatic scientific equipment, and many important results have already been obtained.

Dr. Spitzer said that what scientists hope for along these lines is a satellite observatory, shot up around the earth at five miles per second, and circling our planet indefinitely. A satellite up above the atmosphere all year long could obviously make many more measurements than a rocket that stays up for only a few minutes.

In addition, it would be possible to place an astronomical telescope on a satellite which would offer the astronomer enormous advantages over telescopes on earth, whose effectiveness is limited by the unsteadiness of our own atmosphere.

With a 200-in. telescope, on an earth-circling satellite, objects in the sky could be effectively magnified 10,000 times, while the unsteadiness of our atmosphere usually prevents telescopes on earth from magnifying objects more than a few hundred times without blurring.

Human observers would not go along in such satellites because it would be impossible to bring an observer back from such a satellite without bringing the entire satellite down to earth. Radio waves would therefore be used both to control the equipment and to bring back the information obtained.

Turning again to the question of interplanetary travel, Dr. Spitzer pointed out that since the moon is closest, the first interplanetary trip would almost certainly be to the moon and back.

But the space ship would probably just circle the moon once and return to earth. Landing would be much more difficult. To land on earth, one would use the atmosphere as a brake to slow the ship down, using wings for support.

The moon has no atmosphere, and a space ship would have to slow itself down by its rockets. This would consume a prohibitive amount of fuel. Besides, we know that the moon is a dead and airless world, and not much would be gained by landing there.

On the whole, it is more likely that men will set foot on the planet Mars before they land on the moon. We know that Mars has an atmosphere, and therefore a space ship could glide gently down to the surface in the same way that it would land on the earth.

Mars is the only other planet in our solar system on which we think life similar to ours may exist. The surface turns green in summer and brown in winter, just as our forests and plains would look as seen from another planet. And there seems to be a network of fine lines encircling the planet that may be canals constructed by intelligent beings.

He declared that it is quite possible that intelligent life exists on Mars and that some astronomers would even say probable. If life on Mars developed a little earlier than on earth, it is possible that the Martians may have been civilized for millions of years, as compared with our thousands. In such a case, their scientific knowledge and their ability to contact Nature would of course be enormously greater than ours.

If intelligent life does exist on Mars, with interplanetary travel probably only a few decades away, we may be approaching the most momentous event in civilized history.

British Aircraft Outlook

A TALK on British aircraft-propulsion developments to be expected in the next 10 or 15 years, was given by F. R. Banks, technical manager, Associated Ethyl Company, Ltd., England, at a meeting in New York, N. Y., sponsored jointly by the Metropolitan Sections of The American Society of Mechanical Engineers and the Society of Automotive Engineers, and the New York Chapter of the Institute of Aeronautical Sciences.

Mr. Banks declared that the end of the high-duty piston-type aviation engine could now be fairly accurately forecast. With the exception of some small feeder-line and taxi machines, none of the forward types of British aircraft were to be engined with piston engines and all were having jet- or propeller-turbines. This meant that the piston engine was already on its way out, but since it would be about five years before prototype turbine-engined aircraft could be ready to fly on the air routes, and because it would take some further years to build up experience and numbers in this class of aircraft, the present types would exist for about ten years.

Present piston engines in England such as the Rolls Royce "Merlin," "Griffon," and "Eagle," and the Bristol "Hercules" and "Centaurus" types would persist in their present forms for a number of years for obsolescent commercial and military aircraft and until the gas-turbine replacements come along. So far as is known, no more new piston engines would be built by the British manufacturers.

Turning to the gas turbine, Mr. Banks stated that both the jet turbine and the propeller or power turbine had their place in commercial and military aviation, although the British were at the moment developing the propeller turbine mainly for commercial-airline use. The jet turbine was accepted by the British for military and commercial operation.

Of the two basic types of blower used in gas turbines, namely, the centrifugal blower and the axial type, he thought the centrifugal blower would eventually be ousted by the axial type because the axial offered higher efficiency and it could deal with more air for a given over-all diameter.

The jet turbine would be used both for short as well as relatively long-range aircraft. This was interesting because it had not so far been thought feasible to utilize jets for normal intercity airline operation.

Longer ranges than 3000 miles (4000 miles in still air) for aircraft fitted with the jet turbine were not foreseen. The propeller turbine would probably be used for the longer-range aircraft. Propeller turbines at present under development in England would be used in moderate-range and moderate-altitude aircraft, cruising at about 300 mph. This excepted the Bristol Barbazon I which was intended for the North Atlantic route, and therefore long range. It would be powered by economical operating propeller turbines.

In discussing the propeller turbine, the speaker gave his opinion that propeller efficiencies of 80 per cent were quite possible of achievement up to 550 mph.

He did not consider the piston engine to be a competitor of the propeller turbine because both military and commercial airplanes would be operating at high speeds and would therefore need very large powers. Although it would no doubt be possible to build large piston engines, it was certainly not worth

the time and effort involved. What was more important was that the piston engine of comparable power to the propeller turbine would have an enormous built-in drag which would more than outweigh any economy in specific fuel consumption that the piston engine might give. In any case the propeller turbine could achieve the equivalent specific fuel consumptions of the piston engine at its cruising condition which would be a high percentage of its full power. The specific weight of the piston engine almost doubled itself immediately after it got into the air because most piston engines were throttled back to about 50 per cent of their take-off power at cruising conditions.

On the question of high-speed aircraft for the commercial airlines when the turbine had reached the necessary state of reliability for such aircraft, Mr. Banks said that there would be a number of problems centering around the passenger. At present cruising speeds, passengers had been quite seriously hurt in "bumps" and he wondered what would happen to them at cruising speeds of some 250 mph greater than the maximum cruising speeds of today. It was wrongly thought that there were no bumps at altitudes of 35,000 and 40,000 ft. There were quite severe bumps at these altitudes and over continental America, in summer, and in subtropical and tropical climates.

A final point about high-speed commercial aircraft concerned their operation on the routes, since such aircraft were virtually "constant-speed" machines and could at no time exceed their critical Mach number. Their angles of descent would therefore be flat and unless some method of air-braking were used, the pilot would have to start descending at a very low rate as soon as he had reached operating altitude. This might not be practicable on short journeys. Another method of braking, in order to steepen the glide path, would be to deflect the jet stream in a forward direction.

Wear-Measuring Gage

A MAJOR difficulty in the determination of the wear of machinery surfaces has been the lack of a convenient method for accurately measuring the amount of material worn off. Methods that have been used widely are weighing and measuring the dimensions of parts before and after wear, and determining the amount of worn material found in the lubricant after operation. The weighing method gives a value for the total wear but does not indicate where the wear occurred. Measuring the changes in the dimensions does not differentiate between actual wear and other changes that may occur such as growth, shrinkage, or distortion of the part. The method of determining the amount of worn material in the lubricant presents a number of difficulties and usually is used only as a qualitative indication in conjunction with other data. Even under ideal conditions these methods have serious limitations.

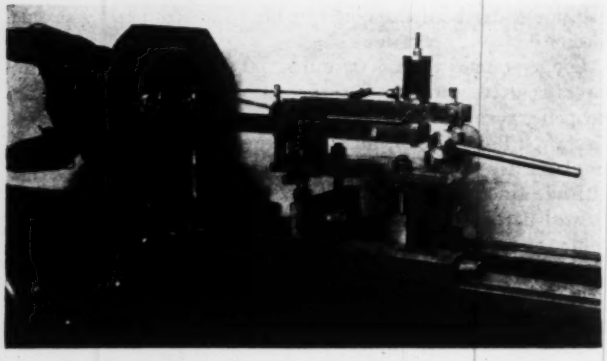


FIG. 3 VIEWING AND MEASURING APPARATUS USED WITH WEAR GAGE

(In this setup the apparatus is being used to view and measure the changes in dimension of a mark placed on a piston surface in order to determine the amount of wear.)

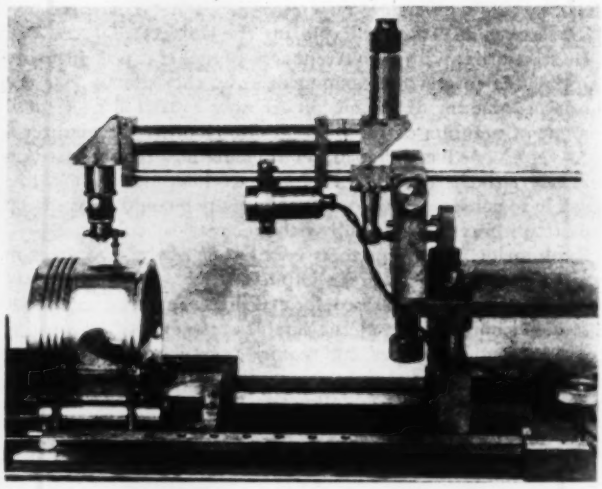


FIG. 4 APPARATUS FOR MEASURING EXTREMELY SMALL INCREMENTS OF WEAR BY DIAMOND-INDENTATION METHOD

(An aircraft-engine cylinder is shown mounted in a special fixture with the gage in position to make a mark on the cylinder surface.)

Investigations conducted at the National Bureau of Standards under S. A. McKee led to the adaptation of a diamond-indentation method of measuring wear. As a result, a sensitive wear-measuring gage was developed to measure extremely small increments of wear, as little as 0.00001 in. under favorable conditions. This is said to be considerably less than with other methods. By applying to the working surfaces narrow diamond-shaped markings that show a definite change in one or more readily measurable dimensions after relatively small amounts of wear, the gage provides a determinable indication of wear at the point where the marking is made.

The gage was designed primarily to locate and measure indentation marks on the cylinder walls and pistons of radial aircraft engines, since permanent distortion of such parts during operation had heretofore nullified the significance of any previous methods of measurement. The choice of the type of mark was influenced by the Knoop indenter for measuring the hardness of materials.

With a cylinder or piston mounted in a specially designed fixture, marks are applied at any desired position on the surface by means of the diamond point which is forced by mechanical pressure to a predetermined depth into the surface of the piece. The viewing and measuring apparatus consists of a conventional microscope and eyepiece scale, modified by the addition of two right-angle prisms so that it may be used as a periscope for viewing the inside of the cylinders. See Figs. 3 and 4.

The impression of the marks in the surface of the metal raises a burr around the mark. The shape of the diamond indenter is such, however, that the major portion of the burr is formed on the sides of the mark. Though no burr is visible to the eye at the ends of the marks, the presence of a slight elevation of the surface may account for the minor deviations from a straight line shown by calibration curves. In the course of the investigation it was found that most of the burr could be easily removed by rubbing lightly with fine polishing paper. For use with the cylinders, a sheet-metal guard similar to the usual erasing shield but of larger dimensions was found convenient.

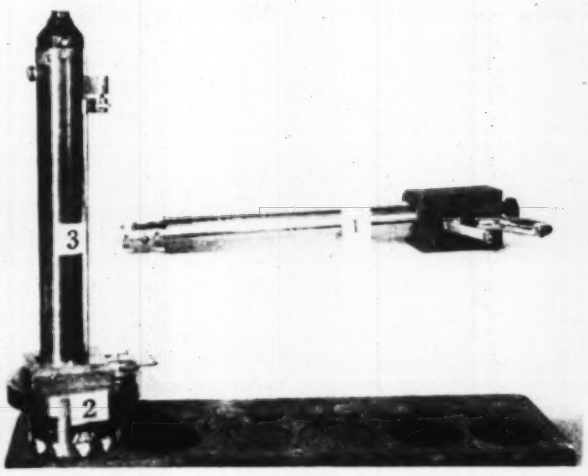


FIG. 5 WEAR GAGE AS DESIGNED FOR USE WITH AUTOMOBILE ENGINES

(The three components of the instrument are 1, indenting tool; 2, indentation locator; and 3, microscope.)

The holes in this guard are so arranged that the polishing paper can be rubbed over a small area at each mark on the cylinder wall with one finger.

As the marks are placed with their long axes perpendicular to the axis of the cylinder, the relation between the change in depth of mark to change in length of long axis is affected by the curvature of the cylinder. While this effect is relatively small for the particular cylinder used, suitable corrections for curvature provide greater accuracy in determining wear.

A study was also made of the possibility of error due to the axis of the diamond indenter not being at right angles to the surface when the indentation is made. Computations indicated that if the diamond-shaped mark was symmetrical to within a ratio of not less than 41 to 50 along its major axis, the error would be no greater than 1 per cent (approximately 0.00001 in.). It was found that the apparatus could be adjusted to produce a symmetrical mark and that other marks, either in the same cylinder or in other cylinders of the same nominal size, could be made well within the limits of symmetry without further adjustment. Accordingly, corrections for lack of symmetry were not found necessary.

An important consideration in the investigation was the uncertainty as to whether the marks would return to their shape during operation of the engine. Results of a number of engine tests have shown that marks in the cylinders of radial aircraft engines retain their shape sufficiently to provide reasonably accurate wear measurements. Experience has indicated that results are not as satisfactory after the marks have been worn to about one fourth of their original length or less.

The precision of the wear measurements depends upon the condition of the indentation. With new marks the points are sharp and the lengths can be accurately determined. However, after the engine has been operated the marks are somewhat blunted and it is necessary to estimate the position of the point. Under normal conditions the cylinder wear can be determined with an over-all accuracy of ± 0.00004 in. For more favorable conditions the degree of accuracy can be increased to ± 0.00002 in. Operating experience with marks in the pistons indicates that with the softer aluminum alloy the marks have a much greater tendency to distort and the results are not entirely satisfactory. Another difficulty with this material is its tendency to become impregnated with carbon, making it difficult to distinguish the marks.

Most of the engine tests for determining the performance of the marks in service were made with Pratt and Whitney R-1535 engines having chrome-molybdenum-steel cylinder barrels $5^{3}/_{16}$ in. in diameter. In these tests 24 marks were made in each cylinder, 6 spaced 60 deg apart at each of 4 levels—approximately 2, 4, 6, and 8 in. from the open-skirt end of the cylinder. The upper row of marks was in contact with the top ring only while the lower was contacted by the oil ring. Typical cylinder-wear patterns obtained in these tests reveal unsymmetrical wear with respect to the axis of the cylinder that would be impossible to determine with usual measurements of diameter.

Employing the basic principles of the original gage, an instrument was designed by the American Instrument Company for use with automobile engines in which the cylinders are cast into a single engine block. This instrument, used in a series of tests, permitted accurate studies of the effects of wear in stock passenger-car engines operated under controlled conditions. The test engines were operated for 144 hr (approximately 3000 miles of normal operation) between wear measurements, the operating cycle consisting of 20 min of actual operation with a 10-min stop for cooling. During the stop period a special cooling system reduced the temperature so that the engine was started from a cold condition at the beginning of each half-hour period.

Results of these tests showed the average cylinder wear to be about 0.00002 in. per 1000 miles of operation, verifying a previously accepted theory that operating conditions have a decided effect on cylinder wear, there being in general a greater amount of wear when starting the engine at low temperature than at high temperature (50 C). The data provided by such sensitive determinations of wear also indicated the possibility that corrosion is responsible for a major part of the wear occurring in normal operation of the engine. It is believed that moisture condensing on cold cylinder walls serves as a base for the formation of corrosive acids from the gases in the products of combustion. It appears that engine life may be substantially

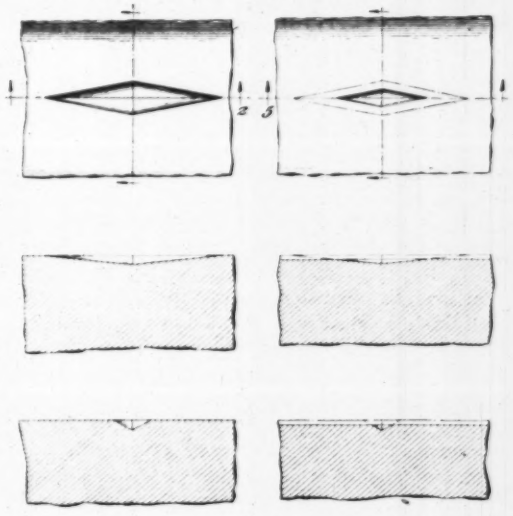


FIG. 6 DIAGRAMS OF TYPICAL INDENTATION MADE WITH WEAR GAGE

[Views, at the left (*top to bottom*) are the plan, longitudinal, and transverse sections of a mark before wear has occurred, while those on the right are the same mark after material has been worn from the surface. Note that the shape of the mark remains the same, but the length decreases in proportion to the thickness of material removed.]

increased by any feature of design that accelerates the engine warmup or prevents the temperature of the cylinder walls from falling below the dew point of the exhaust gases. Further data on the corrosive qualities of fuels would be desirable.

In addition to its use as a practical method of measurement of wear in aircraft and automotive-engine cylinders, the indentation method appears applicable to other machine elements, gages, dies, and wearing surfaces, where the material is of such a nature that the indented marks will retain their shape in service. For example, a mark placed on the wearing surface of certain production dies would readily indicate when it had been worn beyond specified tolerances.

Wood-Decay Survey

A STATE-WIDE study of the factors influencing wood decay under conditions of modern construction, has been initiated by The New York State College of Forestry at Syracuse University. The study will be done under the direction of Dr. Ray R. Hirt, forest pathologist of the College.

He stated that the co-operation of architects, contractors, and builders of New York State will be sought in order that the results may be of the greatest practical benefit to the public.

The project will include the study of wood decay in year-round dwellings, summer homes, storage plants, office and industrial buildings, and other types of wooden structures. The problem of modern wood preservatives in relation to the control of decay in new lumber as well as in timbers already in service, will form an important part of the investigation.

Dr. Hirt says that heavy demands for wood during the last few years has brought inferior grades of lumber on the market for building purposes. Even some of the better grades of lumber are poorly seasoned when they reach the builder. New methods of building and insulating structures have been developed in recent years and fabricated lumber is steadily coming into use. As a result of this combination of circumstances, decay of building timbers in service is more common than formerly.

Safeguarding Storage Areas

FIRES in storage areas are responsible for almost one third of the total damage experienced in Factory Mutual plants, according to *Factory Mutual Record*, May, 1947. In average, each "storage" fire causes about six times as much damage as fires at manufacturing processes.

The reason is the concentration of value of the stored materials. Raw stock, furthermore, is vital to continuous plant operation. Finished or near-finished goods represent ability to fill orders. The safeguarding of both deserves attention.

A recent analysis of more than 1000 storage fires emphasizes the high lights that must be considered in planning fire safety.

Where you place your storage has an important bearing on its fire safety. Try to segregate it. Especially, keep storage out of manufacturing areas. This will avoid such consequences as followed a fire in an unsprinklered drier at a rubber-working plant last summer. Thousands of yards of rubberized fabric and a large stock of finished raincoats, unwisely stored in the same area with the drier, were severely damaged by fire, smoke, and water, with the result that damage reached $87,000.

Also, avoid locations below manufacturing processes unless the building construction is noncombustible and floors are watertight. Otherwise, water used in fighting fires in upper stories can cause much damage to stock stored on lower floors. In many locations, covering the storage with water-resistant canvas avoids the risk of such wet-downs.

Storage areas need automatic sprinklers if either the storage or the building construction is combustible. A water-flow alarm is usually advisable to assure prompt discovery of fires and to minimize water damage. A strong water supply for sprinklers is also important especially where stored materials are susceptible to a burrowing fire. Keep storage at least 18 in. below sprinklers so that it will not prevent proper distribution of water.

Subdivision is a basic and important safeguard. Where practical, split up important storage between two or three different areas so that a single fire cannot endanger all the stock. Within any one area, subdivide materials into reasonable piles with ample aisles so that fire will at least be limited to a single pile.

High piling of baled stock plus lack of aisles is a bad combination, especially in storage of baled textile fibers such as cotton and jute. At one mill, 900 bales of cotton were piled five high on one side with no aisles whatever. Fire burrowed between the bales and was exceedingly difficult to handle. Ultimately the fire fighters had to break down the piles and truck the cotton into the yard to complete extinguishment. Many bales were severely burned and damage amounted to more than $10,000.

Spontaneous ignition is the most frequent fire cause. Such things as poor housekeeping, rubbish, or foreign material in low-grade storage are behind almost 30 per cent of the fires. Keep the storage areas clean! Also keep low-grade materials, susceptible to spontaneous heating, separate from high-grade stock.

Smoking causes 20 per cent of all storage fires. Storage areas, unfortunately, make good "hideouts" for workers who want to "sneak a smoke." This in itself is sufficient reason for closing such areas to all but those who must enter.

Electrical causes are another major offender. They include such things as defective wiring, arcing at extension cords to stackers or hoists, and light bulbs in contact with combustible material. All electrical equipment in storage areas should be of good quality, well installed, and carefully maintained.

Cutting and welding near combustible storage is extremely risky and has caused many bad fires. Unless the storage can be removed, some other cutting or fastening method may be the only solution.

In recent years gasoline-powered industrial trucks have caused an increasing number of storage fires. Factory Mutual Bulletin No. 11.24 contains helpful pointers to anyone operating such trucks in storage areas.

Skids 4 in. or higher, plus floor drains, are invaluable in storage areas for preventing damage from water collecting on the floor beyond the immediate vicinity of the fire, particularly in basement areas. This is one of the added advantages of pallets now widely used in moving and stacking materials.

Belgian Industry

SOME interesting and informative facts concerning industry in Belgium were revealed by Graham W. Parker, member A.S.M.E., partner, Parker and Strackbein, New York, N. Y., in a talk which he gave recently at an Overseas Rotary Luncheon in New York. Mr. Parker is an industrial consultant to European factories and visits Europe at least every three months.

He said that war damage was not too great except in a few localized areas; and throughout the country people are working hard. Belgium, with her known gold and dollar holdings of about $800,000,000 is rather well placed from an exchange point of view, and has been proving to be a good customer for American goods. Roughly, the internal price level is about

320 per cent of the prewar level. In many fields, the present production of goods is 10 to 20 per cent above the prewar average, and the over-all production average is about 108 per cent of prewar output.

Steel production is still below prewar but has risen steadily over the last 18 months. The steel industry around Liege, in 1939, turned out about 250,000 tons of pig iron per month and now is working its way up to about 230,000 tons monthly.

In cotton textiles, typical prewar production was some 6,000,000 kilos of yarn per month; production for March of this year was 6,300,000 kilos. In wool yarn, production has gone up from 2,000,000 kilos per month in 1938 to almost 3,500,000 kilos monthly for the first three months of this year.

In Verviers, one of Europe's greatest wool centers, the warehouses are filled with Australian and South American raw wools and the only things that keep production from going even higher have been the past winter's coal troubles and an acute shortage of weavers. In one mill, about 20 per cent of the looms are idle because of the scarcity of weavers.

In order to obtain more yarn, some of the Verviers weaving mills have started to subcontract the work to German mills. The usual arrangement was that the Belgian mill would supply the German spinner with two kilos of raw wool to get back one kilo of finished yarn. The German spinner keeps the other kilo as payment for his labor, overhead, and profit.

Wage rates in the Verviers mills are ranging from about 13 to 18 Belgian francs per hour. To this must be added 25 per cent social charges. In one Belgian tannery visited, the exact average hourly rate was 14.92 francs. Adding the social charges and taking the Belgian franc at 44 to 45 per dollar, a total wage cost of about 42 cents per hour is obtained.

In other plants in Belgium and in factories in the east and north of France, it can be said that current labor rates are generally between 40 and 50 American cents per hour.

A plant near Brussels, with about 1200 employees, has just taken on a woman as director of personnel relations—an unusual post in itself in Europe—and is launching a far-reaching campaign of management-labor co-operation. Some of the big companies in Brussels are doing quite a bit to sponsor a so-called scientific approach to the problems of human relations in industry.

Machines and tools have taken a beating over the last seven years and the average Belgian factory owner is looking at this problem of plant modernization seriously. Some of the factories have already been modernized. One of the few textile mills that had been completely destroyed, near St. Nicholas in Flanders, has already been replaced by a new modern one-story building with a good deal of new machinery in place and ready to produce. Another plant, which is fortunate in that it can enjoy relative mass production in a small market, is installing complete new mechanized production lines, some of them American equipment, that are expected to cut pay-roll costs by about 40 per cent. A number of wool and jute mills have large orders placed in America, France, and Switzerland for new automatic looms, continuous dyeing and finishing machines, and other high-production equipment.

A producer of steel office furniture is building a new plant and is equipping it with practically every modern mechanical feature that could be found in a similar plant in the United States. A construction-engineering firm in Brussels is building a completely air-conditioned factory, rather small, but it will probably be the most modern postwar plant in the country. Even during the war, factory construction was not completely halted. A modern rayon plant was built and proved to be a great asset to Belgium in 1946 in recovering some export trade.

But for a great many companies in Belgium the job of re-equipping or replacing old machines is not easy. Many corporations had a heavy drain on their cash resources during the war years and today have to work with insufficient floating capital or working capital. With the changed price level, they do not have the francs on hand to buy what they need, and it is hard to see just how some of them are going to solve this problem. The government has had plenty of immediate problems of its own, and, insofar as is known, has not come up with any major program for the industrial re-equipment of the country. It is up to private industries to economize and do the best job they can. As for Belgium as a future market for American machinery and other products, there are two developments that should permanently increase its economic importance, namely, the long-awaited Belgian-Dutch customs union, which will bring together Holland, Belgium, and Luxembourg as a single economic unit by the end of the year; and the growth of the Belgian Congo.

From an export manager's point of view, the customs union will mean replacing several separate small markets by a single market of some 17,000,000 highly-industrialized people. There will be many adjustments, and some individual losses, but the net results should be a stronger economy all around.

As for the Congo, the big wartime copper and uranium exports have dramatized the colony, but many other factors have made people realize that the Congo is an important economic asset for any country to have. Many are going to the Congo to start a new business, to develop a quinine plantation, to start a large-scale farm using American tractors, or expand one of the refineries. Business organizations are taking another look at its market position in the colony and are sending another man down there or opening up a new branch.

Helicopters

AT THE recent annual meeting of the American Helicopter Society, Jerome F. Lederer, member A.S.M.E., chief engineer, Aero Insurance Underwriters, New York, N. Y., presented a paper in which he discussed various factors that would affect helicoper insurance rate levels, rate differentials, and risks, now that helicopters are coming into civilian use.

One point which Mr. Lederer brought out should be worthy of some attention by designers, engineers, and manufacturers, not only of helicopters but any device made for consumer use.

He stated that it is of the utmost importance for manufacturers to make the helicopter as easy as possible to inspect because once it leaves expert hands the new owners cannot be depended upon to be as careful with it as the manufacturers or dealers. When laying out inspection and maintenance features, engineers should design to the level of the laziest person that they could imagine. One helicopter manufacturer has taken great pains to study this particular situation and has provided built-in steps and platforms for the mechanic to inspect the rotor mechanism and other parts.

It would be advisable for each manufacturer to appoint a committee to meet at least once a month to discuss what can be done to improve the helicopter from the viewpoint of facilitating maintenance and loss prevention in the field. This committee should consist of an engineer, a test pilot, a production test pilot, and representatives of the sales, production, and service departments. Personnel for this committee should be appointed on the basis of ability to think objectively and to be open-minded about adopting new suggestions. There must be no face saving, no mental inertia, no disrespect or disdain for the users of the helicopters who make blunders. The people who blunder are probably the average persons to whom the helicopter must be sold. This committee should not pass

operational or maintenance mistakes on to a manual by saying why didn't the pilot or the mechanic follow the book. (The size of a manual is often in direct proportion to the ability of the engineers to design a simple mechanism. The ideal mechanism should not need a maintenance or an operations manual.) It is felt that once a person learns to fly or operate any machine he becomes illiterate and seldom follows the printed word. The machine has to be designed to suit that mental approach.

Nuclear Energy School

OPENING of a new school at Oak Ridge, Tenn., for scientists and engineers conducting research on the use of Nuclear Energy for the Propulsion of Aircraft has been announced by Fairchild Engine and Airplane Corporation.

Six courses will be given. The first three courses, which began June 10, will continue for three months. The last three courses began in July and will run about two months.

The program for the study of nuclear energy for the propulsion of aircraft, known as the Fairchild-N.E.P.A. project, is a combined operation of ten aircraft-engine companies and the National Advisory Committee for Aeronautics, working with the Fairchild Engine and Airplane Corporation as prime contractor under the Army Air Forces. The Atomic Energy Commission is co-operating in the program. Information developed by N.E.P.A. will be made available to the Navy through liaison with the Office of the Assistant Chief for Research and Development, Navy Bureau of Aeronautics.

This training school is the first to be organized for the purpose of instructing N.E.P.A. personnel and representatives of the companies participating in the program. It follows a ten-day seminar for engineers of the participating companies, Army Air Forces, and Navy Bureau of Aeronautics, which was conducted at Oak Ridge in February.

The present program represents a desire, N.E.P.A. officials said, for more elaborate and organized training in nuclear science, engineering, and mathematics. The six courses of instruction include: Nuclear Science and Engineering, Descriptive Survey of Aircraft Engineering and Pile Application, Experimental Nuclear Physics, Metallurgy, Survey of Mathematics, and Nuclear Chemistry.

Equipping Office Workers

ONE of a series of letters written by C. F. Braun, president, C. F. Braun & Co., Alhambra, Calif., and issued in pamphlet form to its employees, brings forth some noteworthy facts concerning the tooling and equipping of the office worker. Parts from Mr. Braun's letter which might prove interesting follow:

Every progressive industry is continually studying its tooling, improving it, increasing it. Yet for years there has been a strange and almost universal blind spot. The tooling of the office worker has had almost no attention.

Nobody hesitates to equip a truck driver with a $6000 truck. Its fair economic life is, say, six years. Thus we spend $1000 per year on tools for our truck-driver. Or consider a machinist—a fair-sized drill press costs $10,000, and reasonably lasts 10 years. Again $1000 per year spent on tooling our man. In these cases, the stockholders, that is, the tool owners, have been doing their part of the job pretty well.

But what about tooling for the run of office worker? What has industry been doing for him? It has given him a stingy patch of floor space in a group room, a cheap table, a cheap stool or chair, some wire baskets, bad light, some cheap hard floor covering. Total investment, maybe $2000. And as a rule, the stuff is used for 40 years—say, $50 per year spent on tooling the man. Beyond the shadow of a doubt, the stockholder here has done practically no job at all.

We find engineers, designers, draftsmen, accountants, others, herded together in group-rooms, in "bull pens." No second of the day without disturbing interruptions. Everywhere noise and confusion, dirt and heat. And, as a rule, stark ugliness. No slightest suggestion that the group warrants respect and consideration. No suggestion that each man is an individual. Nothing to invite his interest in his work, or his pride in it. Nothing certainly to make him love his employer or his job.

Now suppose we change all this, as is being done at Alhambra. Give each office worker a private office. Not a large one—100 square feet is enough. Then make it comfortable and pleasant—carpeted, well-lighted, air-conditioned, and with acoustic ceiling. Furnish it well and attractively. Give the draftsman, for instance, a desk and chair plus his table and stool. Build in a bookcase, coat cabinet, supply cabinet, for everyone. Adopt pleasing lines and colors. Make the whole setup really first class. Cost, say, $3500 per office. Use it 25 years. We spend $90 per man-year more than for bull-pen space. And what do we gain?

In a private office, our mental worker can concentrate and he can work fast. He is not distracted. He is not interrupted His books, his drawings, and the other things he works with are handy in desk or cabinet. His air conditioning keeps him cool or warm without his fiddling with windows, transoms, radiators, or fans. He is free from outdoor noises. And both he and his papers are free from dirt and free from drafts. How can anyone doubt that he'll do a quarter to a half more work?

And, of course, when we put a man in a private office, up goes his morale. He has more interest in his job, and he'll do it better. He has more respect for his work, and for himself—and will thus have more respect for his time. He is much less likely to waste it, or to permit others to waste it. He becomes the guardian and conserver of what we pay him for, that is, his time. A private office works mightily and swiftly to bring these things about. Put a man in a private office, and almost at once, a change of bearing, and dress, and attitude, becomes plainly apparent.

Furthermore, there is the important factor of respect by others. When any group of workers are herded into a large room, they lose caste. Neither they, nor their work, nor their time, are held in proper respect by others. There is a strong tendency throughout the organization to feel that the time of such a group is cheap. Their time is used without proper consideration. Put them in private offices, they become respected, their time is used with care.

Fighting Forest Fires

THE use of standard Army Air Forces aircraft in fighting forest fires will be tested soon in the Lolo National Forest near Missoula, Mont., in a project sponsored jointly by the A.A.F. and the U. S. Forest Service.

Two Republic P-47 Thunderbolts and a Boeing B-29 Superfortress will drop standard auxiliary fuel tanks filled with water. The tanks will be equipped with fuses set to explode the tanks at a predetermined altitude so that the water will be scattered over the greatest possible area to be effective. Tanks filled with chemicals will be tested in the same manner.

The experiments will determine if forest fires can be extinguished before they spread into raging infernos. Each year forest fires destroy an average of 31,000,000 acres of valuable

timber before they can be brought under control. It is the hope of the sponsors of the experiment that aerial firemen will be able to strike quickly while a blaze is small, even in the most remote forest areas.

If the tests are successful with the use of standard aircraft, the Forest Service and the A.A.F. expect to be able to call into action a number of operational planes from any A.A.F. base near a fire. The only special equipment necessary would be the auxiliary fuel tanks equipped with fuses.

The project was started in October, 1945. Preliminary tests have been carried out at Air Proving Ground Command, Eglin Field, Fla., with highly satisfactory results. The tanks were modified at Eglin Field at the expense of the Forest Service.

The B-29 will carry eight tanks. One tank will be carried under each wing of the P-47s.

Aircraft have been used to advantage in spotting forest fires in the national forests for a number of years but this will be the first actual experiment in fighting the blazes from the air.

Rocket Research

COMPLETION of a series of 20 powered flights over the Army Air Forces' Muroc Flight Test Base, Calif., by the Bell XS-1, together with delivery of the second of these airplanes to the A.A.F., marks the end of the primary test program and opens the way for further research by the A.A.F. and the National Advisory Committee for Aeronautics with these rocket ships.

It is expected that further flights of the XS-1 will be made to collect additional information about the way airplanes behave in the ranges approaching the speed of sound.

The second XS-1 will be used to explore flight possibilities in a man-carrying airplane at even higher speeds.

Precisely how fast the XS-1 will be flown is conjectural, and dependent upon many factors, but it is to be noted that the airplane is designed and powered to reach a maximum speed of 1000 mph. When equipped with a specially designed turbopump which permits carrying a substantially greater load of liquid oxygen and alcohol, the XS-1 will have a speed potential of 1700 mph.

To date, the XS-1 has been intentionally limited to speeds of 0.8 Mach number, or 8/10ths the speed of sound, which is variable, ranging from approximately 760 mph at sea level to 660 mph at 40,000 ft, the decrease being due to altitude and temperature.

Hitherto classified information is disclosed about the XS-1 and the problems faced in launching the research program for which it was designed.

Two sets of wing panels have been built, one with a 10 per cent chord and the other 8 per cent. With a 74-in. root chord, the maximum wing thickness in the first instance is 7.4 in. and 5.9 in. in the second. Because of the fact that the entire plane was designed to withstand strains of 18 g (18 times the force of gravity) conventional wing construction was not feasible, and instead, machine-tapered 75S-T aluminum-alloy skin was used to carry the bending loads. At the butt, these wing skins are 0.45 in. thick.

Two sets of stabilizers were also made, one 8 per cent thick and the other 6 per cent. Instead of a machine-tapered skin, however, a laminated construction was used, with two laminations at the inboard end and one thickness at the outboard end.

The control system is conventional, using push-pull tubes in the cockpit and tension rods aft of the cockpit, running through the dorsal fin. Hydraulic dampers have been designed and built, and have been installed in the elevator, rudder, and aileron control systems to reduce, or possibly eliminate, flutter or buzz effects which, it is suspected, may develop as the XS-1 comes closer and closer to the speed of sound.

From front to back, the internal arrangement of the XS-1 is almost entirely a collection of shaped tanks carrying fuel and liquid nitrogen, leaving only additional space for the pilot's cockpit and the 500 lb of instrumentation which the N.A.C.A. has installed for observation of flight characteristics.

In the nose, immediately in front of the cockpit, is a small cylinder containing nitrogen under 4500 psi, and directly behind the pilot are seven similar nitrogen spheres, with the tank holding 313 gal of liquid oxygen located next. The compartment for the instruments and main landing gear was found to have room for still another pair of nitrogen spheres, while aft of the tank holding 298 gal of alcohol-water mixture were the final two nitrogen cylinders, which make a total of 11, and range in size from 15 to 21 in. in diameter. The four-cylinder rocket motor, manufactured by Reaction Motors, Inc., is located in the tail.

Although capable of taking off under its own power, the XS-1 has always been launched at altitude from a B-29 "mother ship." The reason for this was that inasmuch as the craft was purely a research vehicle, there was no point in dissipating a substantial amount of the limited fuel load—which in the model without the turbopump enables approximately 2.5 min of flight at full power—in taking off and climbing to the altitudes desired before the problem under study would be faced.

In flight, one man rides alone, but to make that flight possible a team of technicians, rigidly rehearsed and working with utmost care, man the evaporators used in fueling oxygen and filling the nitrogen spheres, the mother ship, and all the other equipment needed to make possible this probing into the unknown.

Wire Conveyer Belt

A STEEL-GRID conveyer belt that is reported to be able to turn corners without tipping, describe a complete circle if necessary, move a product uphill or down, or horizontally straight ahead has been designed for industrial-process lines, with special space requirements, by Cyclone Fence Division of American Steel & Wire Company, United States Steel Corporation subsidiary, in Waukegan, Ill. Its open construction also permits the air circulation required for cooling a lightweight product while in motion. A section 2 ft wide weighs only 3 lb per linear ft and is made in bright, galvanized, tinned, or stainless-steel wire as may be most desirable to meet special conditions in manufacturing operations.

Thus the cooling-belt lines of a baking plant, for example, may be designed to hug the walls, turn as many corners as necessary, and to stack flights to ceiling heights with as little as 10 in. between loaded faces. It is said that there are no lubrication problems, and because steel wire is used, no difficulties result from fats, oils, greases, fumes, or heat.

Necessarily, the belts must be assembled to meet the needs of the individual user's design, taking into consideration such problems as service life, speed of transfer, weight, power required to operate, and slippage. As the belt is assembled from individual straight, stiff wires, it is possible to compensate wear factors by replacing one or more links at a time, a simple and easy operation.

The belt is made from No. 9-gage steel wire assembled on $1/2$-in. centers and is available in standard widths, from 6 in. to 2 ft, in straight lengths, or curved sections. Normal construction involves lengths up to 40 ft.

In the baking industry, this type of conveyer is said to be

replacing cooling racks, thus eliminating the trucks, artificial cooling chambers, and exhaust fans normally required. As an instance of compactness, one doughnut cooler has been designed to use a series of 15 tiers of flights in a space 28 ft long, 2 ft wide, and 9 ft high. The product cools more evenly and quickly and can be delivered more promptly from the ovens to loading stations, assuring a fresher, more tasty product.

Electrostatic Painting

THE use of the Ransburg electrostatic spray process in applying finishes in the automobile garnish molding field is discussed in an article by Glenn Ferdon, plant manager, Detroit Moulding Division, L. A. Young Spring & Wire Corporation. The contours of the moldings and their openness preclude dipping from both a production and quality standpoint, and, for the same reasons, finishing by hand spray has proved highly wasteful in material overspray.

The Detroit Moulding Division has for some time used electrostatic spray to apply ground coats on all moldings produced, and are now in the process of installing another electrostatic unit to apply the finish enamel coat so that all painting, with the exception of graining on certain moldings, will be done in an electrostatic field.

The entire finishing operation, except for graining, is conveyerized. All sizes and designs require a ground coat and are handled on the same line.

As the final forming operation is completed, moldings are hung on eight-inch centers on an overhead conveyer, which carries them through the various finishing stages.

Application of the ground coat with the electrostatic process is done inside a single straightaway, double-end booth which has an electrostatic coating field operating in each of the two booth sections. Guns are positioned at both ends of the booth so that some coating material is sprayed into the electrostatic field as the moldings move away from the guns, and some material is sprayed into the field as the moldings move toward the guns.

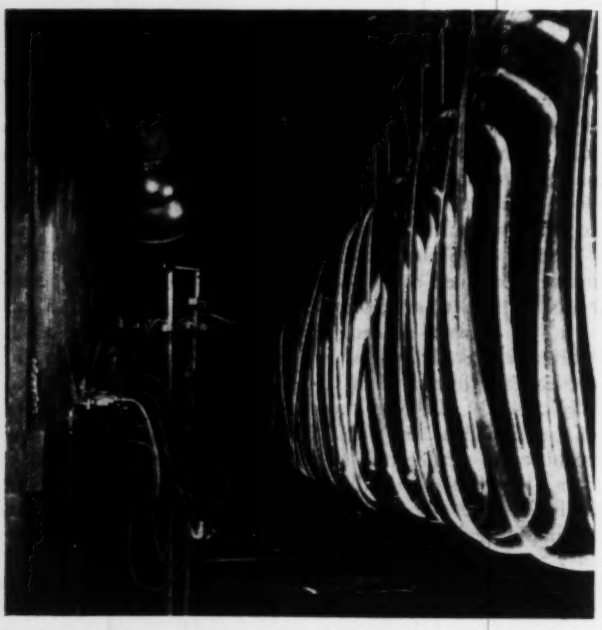


FIG. 7 MOLDINGS START THROUGH THE DOUBLE-END BOOTH AND COATING STARTS AS THEY ENTER THE ELECTROSTATIC FIELD

All of the guns are on fixed standards, four guns at the incoming end, and five at the exit end of the booth, and positioned in a pattern so that one or more can be cut in or out, depending upon the size of the piece. Only on the large pieces, however, requiring relatively more coating material, are all guns operating at any one time. Quarter lights, for example, use only one gun at each end of the booth.

The electrostatic spray process is based on the electrical principle that like charges repel while opposites attract. Wire electrodes are installed inside the paint booth and the parts move through this area on a conveyer. As the atomized paint is introduced into the area, or "coating zone," and the parts move through it, the paint becomes negatively charged through the electrostatic field set up through the action of the electrode system and other special equipment. Although the paint becomes negatively charged, the moldings are of opposite polarity inasmuch as they are grounded by the workholders and the conveyer. Thus the paint is repelled from the electrodes because they are both negative in charge, and is attracted to the positive polarity of the electrically grounded moldings. While the equipment is charged to high-voltage intensity, amperage is extremely low, less than 10 milliamperes at maximum, and the power consumption is less than that of a 1000-watt bulb.

Seven different ground-coat colors are used and the color change to any one of these can be made in a matter of 40 sec or less. Pipes for each color lead into each end of the booth from paint-mix tanks located alongside one wall of the booth. A short flexible connection is provided from this piping to a manifold which feeds the five spray guns. When a color change is required, the lines are cleaned under a blowback pressure of 75 lb which is about four times actual air-operating pressure on the guns, and the flexible coupling is then moved to the proper color connection.

Advantages claimed for this method are: The number of moldings that can be painted per gallon of mixed coating material is doubled; maintenance and booth-cleaning time are reduced to a minimum; a consistent quality of finish coat is assured; the film thickness on each molding is the same as every other molding because the operation is entirely automatic; and a smoother finish is obtained.

Superspeed Rocket

A NUMBER of rockets for test purposes which, it is reported, will reach speeds of 8500 fps, are being built by the Glenn L. Martin Company, Baltimore, Md., for the U. S. Navy, according to the June, 1947, issue of *The Martin Star*.

Named the Neptune, the new rockets will supplant the fast-disappearing supply of German V-2 rockets and will offer many advantages not possessed by the V-2's.

It is said that the 8500-fps speed of the Neptune will be reached when the rocket is carrying a pay load of 100 lb and will occur at a height of 38 miles above the earth's surface at 75 sec after launching. At that height and time the fuel supply of liquid oxygen and alcohol will be exhausted, but the Neptune will "coast" on straight up for another 197 miles to a height of 235 miles, more than twice the height reached previously by a V-2.

In addition to the extreme height which will be reached, the Neptune is said to offer several advantages over the V-2. Although weighing but 10,000 lb empty, the Neptune can carry a pay load from 100 to 1400 lb. The V-2 had a minimum payload factor of 1700 lb, which limited its range.

The V-2 also was difficult to control in flight because it used carbon vanes in the rocket nozzle to control the direction of thrust. In the Neptune, the rocket engine is mounted in gim-

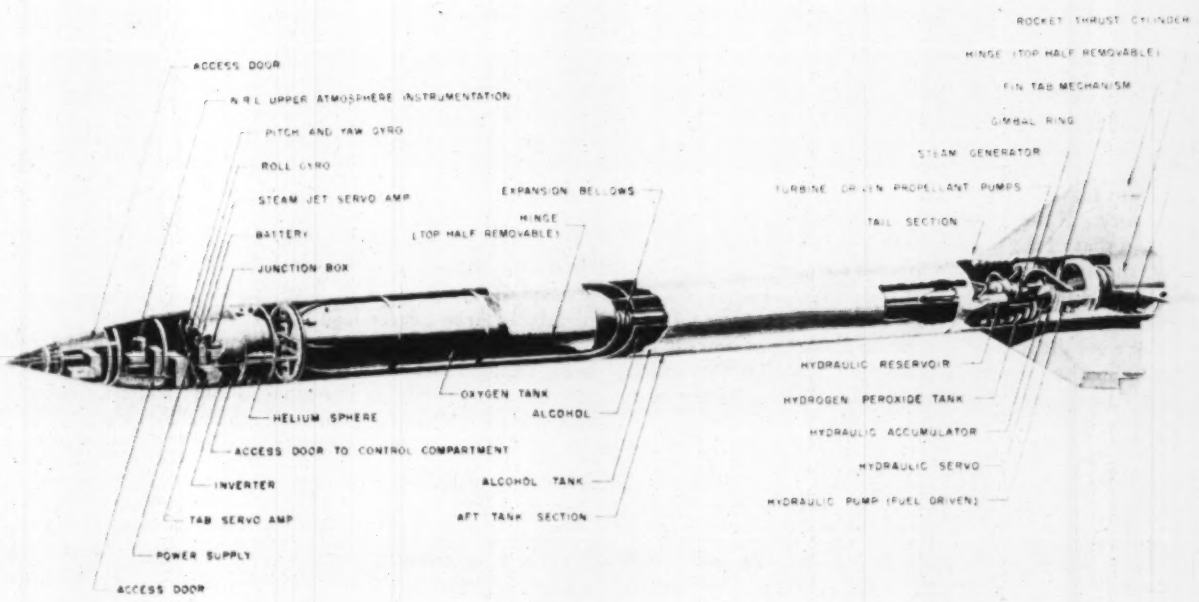


FIG. 8 CUTAWAY SHOWS INTERNAL CONSTRUCTION OF SUPERSPEED ROCKET

bals with a control gyro dictating the reorientation of the line of thrust. This method saves weight and likewise gives a longer burning time for the fuel.

Maximum height and speed in the Neptune will be reached when the rocket is carrying the minimum pay load. Should this pay load be of 500 lb, for example, the maximum height to be reached will be 200 miles, and maximum speed at exhaustion of fuel, 7000 fps. Greater pay loads mean further reductions in speed and height.

Following a test of a small model of the Neptune, the first of the full-sized Neptune is expected to be ready for launching by June, 1948.

The Neptune will be 45 ft long, about the same length as the V-2, but will be much slimmer, being only 32 in. in diameter. Span across the fins will be 98 in. The contract calls for the building of 10 full-sized rockets at a cost of $1,850,000, with delivery scheduled over a three-year period.

One use to which the Navy hopes to put the Neptune is to be able to fire it from shipboard, though no figures have been released to show its possible range when fired horizontally as a rocket weapon. One advantage of shipboard firing, the Navy has explained, is that the Neptune can be used in upper atmosphere research in the equatorial regions. The Neptune is the largest rocket contemplated which can be conveniently fired from shipboard.

A prime factor in stabilizing a rocket is correction of roll tendency. The Navy is attacking this problem by proposing to release steam (generated to motivate a turbodriven fuel pump) from special "roll jets." Release of the steam is controlled by a gyro. Roll control can be extended 17 sec beyond the time the engine cuts off. Engines for the Neptune are being built by Reaction Motors, Inc., Dover, Del.

The U. S. Navy emphasized that the Neptune will be used only for research purposes. Because of its lighter weight, adaptable load-carrying capacity, and both structural and propulsion refinements, the Neptune will be a far more satisfactory missile than the V-2.

Data on temperatures, air pressures, cosmic rays, and other ionosphere phenomena will be telemetered back to the ground for permanent recording and future study.

Reports From Germany

Textile Developments

THE details of German textile developments designed to increase the strength of viscose fibers, to spin two fiber substances simultaneously, and to dehydrate moist synthetic fibers are now available to the American textile industry through the Office of Technical Services, Department of Commerce.

The Germans claim to have produced synthetic fibers with increased dry and wet strength by coagulating viscose in zinc-containing weak-acid baths, stretching the threads in a hot weak-acid bath, and then decomposing them to cellulose hydrate. The baths, composed of 4 to 10 per cent ammonium sulphate, sulphuric acid, and other commonly used salts, contain only 3 per cent zinc sulphate. The strength-increasing treatment produces fibers that are as strong as those treated with three or four times the quantity of zinc sulphate, reduces clogging of holes in the spinnerets, and increases the spinning periods.

Stretching and decomposing the threads which consist partly of cellulose xanthoganto are carried out in water at temperatures exceeding 70 C. The weak-acid condition of the water is produced by the coagulating liquid which adheres to the thread or by adding one per cent to the bath. Two formulas and spinning directions for viscose containing 8 per cent cellulose and 6.5 per cent alkalies are included in the report.

MULTIPLE-HOLE SPINNERET

Another German development is a multiple-hole spinneret with two bottoms which simultaneously spins two fluids and produces synthetic fibers with a core of one substance and sheath of another. The materials used are ordinary viscose, containing 8 per cent cellulose, and the customary viscose spinning baths.

The spinneret is composed of superimposed perforated disks. The holes are arranged in concentric circles. The perforations in the outer circle of disks are of larger diameter than those in

the inner circle but the corresponding holes in both circles are located on identical radii. A control feed line is used for the spinning solution.

In order to center the core of the fiber so that a complete sheath of uniform thickness can be produced, the disks must be properly spaced. The distance between disks is usually 0.1 to 5 mm, depending upon the number and diameter of perforations, and the ratio between the outer and inner spinning fluids and their viscosity. If the quantity of outer spinning fluid is much greater than that of the inner fluid or if the outer fluid has high viscosity, the distance between disks is reduced. The distance also is decreased if the diameter of the perforated areas is small or if holes in the perforated areas are of equal diameter. However, if there is a great difference in the diameter of holes in the inner and outer spinnerets, the disks are placed farther apart. Eight sample spinnings with various fluids and arrangements of disks are described in this report.

HYDROEXTRACTOR

For the formation of fleece, such as rayon staple, the Germans used a hydroextractor in a centrifuge for separating moist or swollen fiber material from the wetting or swelling fluid. It is claimed that the hydroextractor effects savings in manual labor, reduces wear on the centrifuge, and provides a safe means for removing fibers.

The hydroextractor has a horizontally mounted cylinder open on one side in the fashion of a peeling centrifuge. Conveying devices, consisting of endless bands of screening lattices, porous clothes, or other smooth materials permeable by liquid, continuously feed material into the centrifuge and deposit it at the outlet. The bands are arranged parallel to the rotation-axis of the centrifuge close to the cylinder wall with their edges touching so that in cross section they form a uniform square. The conveyer bands are driven by the gear or cylinder of the centrifuge.

The hydroextractor can be used simultaneously as a drier in a long centrifuge. Hot air blown into the hydroextractor flows through the fiber layer in the direction of the centrifugal force. The fiber material is turned by harrows.

A stationary trap cylinder which surrounds the cylinder of the hydroextractor catches the fluid ejected by the cylinder and a funnel-type attachment collects the fluid. The dehydrated material is then deposited by the conveyer bands at the outlet end of the centrifuge ready to be moved to the next stage of processing. The design of the hydroextractor and a modification design are dscribed in the report.

Translated copies of reports PB-31528, "Process for Manufacturing Viscose Fibers of Increased Dry and Wet Strength;" PB-31532, "Spinning With Double-Bottom Spinneret;" and PB-31542, "Continuously Operating Hydroextractor;" may be ordered from Research Information Service, 509 Fifth Avenue, New York 17, N. Y.

Potentiometer

A new type of potentiometer that can compare or measure electromotive forces much more precisely than instruments wound with the finest wire was invented in Germany during the war, according to a report (PB-464) now on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C.

The resistance unit consists of two layers folded together in accordion manner and then compacted under heat into a solid mass. One layer is a very thin strip of paper; and the other, an equally thin strip of Konstantan foil—an alloy of 60 per cent copper and 40 per cent nickel. The resistance unit can be made in any width or shape and can be milled to obtain straight-line, sinusoidal, or similar electrical characteristics.

The side selected for the contact path contains alternate edges of paper and foil. Each millimeter of the path can give as many as 40 gradations in resistance values—many more than the number obtained in the best wire-type potentiometers, the report indicates.

A spring-loaded contact arm moves over the polished contact path with virtually no friction, thereby permitting the potentiometer to be coupled with any low-power precision instrument. However, the slightness of the contact does not prevent the resistance unit from receiving and handling comparatively large current loads.

An experimental model of the complete potentiometer has been obtained and manufacturers and technical organizations interested in examining the model should address requests to Lloyd R. Worden of the Office of Technical Services.

Volkswagen

Design details and construction methods used in building the cheap lightweight German automobile called the "Volkswagen" or "People's Car," are given in a report (PB-L62616) for sale by the Office of Technical Services.

The report, prepared for the British Intelligence Objectives Subcommittee, includes results of performance tests on military and civilian models. A series of parts views and diagrams shows the method of construction. Particular attention is paid to the way in which metal pieces were cut and pressed to shape in forming the body.

Design of the Volkswagen was original in many respects. Mass production was about to start at the factory in Fallersleben near Hanover when the war broke out. The vehicle, with certain alterations, was then made for military purposes. The civilian model was intended to sell for 1000 marks ($400) and prewar plans called for an output of 1000 a day.

Outstanding among design characteristics of the Volkswagen is the rear location of the four-cylinder engine which is cooled by a forced-air cooling system.

The car body is built on a platform of pressed steel with a center "backbone" or tube through which the controls run. Thus there is no chassis in the usual sense, according to the report. Spare tire holder, fuel tank, and luggage compartment are in a sloping projection in front of the driver. The hearing system is built into the body of the car. A control valve enables hot air from the engine to be vented near the floor below both front and rear seats and below the windshield for defrosting.

Although the car is very light, weighing only 1500 to 1600 lb it is approximately normal size—wheel base, 94 in., and length, 13 ft from bumper to bumper. Front track is 51 in. and rear track 48 in. The wheels are individually suspended on torsion rods and the unsprung weight is relatively low.

A second report (PB-27711) contains information on and pictures of the Volkswagen plant, a structure with 19 wings approximately 4000 ft long and 1000 ft deep, part four stories high and part one, with about 4,400,000 sq ft or 100 acres of manufacturing floor space. The building construction was stated to be novel and good-looking with roof supports all made of reinforced concrete.

Colorimetric Iron Determination

Serious time loss in the determination of iron in light metals can be avoided by a colorimetric procedure using sulphosalicylic

acid, according to a translated German research paper (PB-53890) on sale by the Office of Technical Services. It is stated that the colorimetric test gives reproducible values in the presence of almost all the possible alloy elements and impurities.

The colorimetric method shortens analysis time by avoiding the separation of iron, as required in the process of titrating ferrous ions with permanganate. In the colorimetric analysis a small amount of the light metal alloy is dissolved in an acid solution. When the solution is combined with specially prepared sulphosalicylic acid the presence of iron causes the solution to turn red. The amount of iron is measured by using an electric colorimeter with a green filter, according to the report.

The sulphosalicylic-acid test is said to work satisfactorily in the presence of aluminum, magnesium, silicon, copper, zinc, lead, cadmium, antimony, and manganese.

Underwater Power Plants

Additional details on the design and operation of low-head run-of-the-river German hydroelectric plants that combine dam and powerhouse into one structure are described in report PB-65682, the Office of Technical Services announced recently.

Though the over-all design of the novel underwater power plants embodies individual features previously used or known, it represents a radical departure from conventional water-power engineering methods.

Building the powerhouse into the dam not only eliminates the need for a powerhouse bay but reduces the total width of the structure, thus saving time, money, and construction materials.

The dam uses specially designed straight-tube turbogenerator units arranged parallel to the flow of the river water. The turbines are of the fixed-propeller type and contain adjustable guide vanes operated by a servomotor. The generator motor is mounted on the rim of the propeller wheel.

The inlet to the turbine consists of a straight pipe with a flared mouth. The discharge tube is a straight pipe with a cross section that changes from circular to rectangular. Openings between the turbines serve not only as outlets for flood water but also as sluices for sediment and boulders.

A gate in the discharge tube and a butterfly valve in front of the guide-vane apparatus permit engineers to drain the turbines. The mechanism for operating these devices and other equipment is located within the power room of the dam.

The room is a long gallery divided into two levels. The lower level contains the turbogenerator pits and the upper level the hoists for the movable dam which controls the discharge of river water. Entrance to the gallery is through pits on the river bank.

Steelmaking

The 50-ton converters built in Germany during the war may be the most economical way to make large quantities of good basic Bessemer steel, according to a British report (PB-60387) on German metallurgy on sale by the Office of Technical Services.

Sheets for electric transformers with a guaranteed energy loss of 0.9 watts per kg were produced by only one German firm according to another British report (PB-65673) on electrical steel also available from O.T.S.

While 25 to 28 tons capacity has long been standard for German Bessemer installations, recently built 50-ton furnaces have given good results. By using a shallow converter bath, German experts said they could appreciably reduce the nitrogen content of the steel. The quality of this basic Bessemer steel was high enough so that it could often be substituted for open-hearth steel during the war.

Alloy steel has been made in Germany at very low cost by melting a rich alloy charge in a 50- to 60-ton electric-arc furnace, casting this charge in a ladle, and pouring into it open-hearth or basic Bessemer steel. The steel thus made was said to be of uniform quality and low inclusion count.

The production of light alloys was one of the most interesting developments found in Germany. Not only were melting, holding, and casting processes considered noteworthy by the investigators, but outstanding features were also seen in the heavy forging and extrusion presses.

The best German sheet steel for electric transformers was produced from steel ingots supplied by Krupp. The steel had a guaranteed energy loss of 0.9 watts per kg at 10,000 gausses and a frequency of 50 cycles per sec. This steel contained from 4.2 to 4.5 per cent silicon, 0.15 per cent manganese, very small amounts of sulphur, nickel, phosphorus, and chromium, and no aluminum. The maximum carbon content was 0.1 per cent; 0.06 to 0.08 per cent was considered best.

In contrast to British practice, German electrical steel was entirely refined in basic electric-arc furnaces. Krupp used a duplex open-hearth electric furnace system, while Eisen-und-Huttenwerke used a prolonged straight electric process, starting with 90 per cent selected scrap and 10 per cent low-phosphorus pig iron to produce electrical steel with a loss of about 1.1 watts per kg. Thyssen, the major producer, employed both a duplex Bessemer electric process and a straight electric process for the production of its highest grade of electrical steel which had a loss of 1.0 watts per kg.

Rural Telephone Service

THE Bell Telephone System and the Rural Electrification Administration have developed two model agreements expected to have a far-reaching effect in promoting the further extension of telephone service in rural areas, according to an announcement by the American Telephone and Telegraph Company.

These agreements cover (1) The furnishing of telephone service by "carrier" methods over R.E.A. co-operatives' power-distribution wires, and (2) joint use of pole lines of the telephone companies and the co-operatives so that both electric and telephone wires may be carried on the same poles in many rural areas.

The way is now open, it is believed, for widespread use of these two recently developed methods of bringing telephone service to more farm homes. Discussions between the Bell System and the private power companies, looking toward similar agreements, are now under way, and the United States Independent Telephone Association has indicated that telephone companies which are not a part of the Bell System are giving active consideration to contracts of similar type.

Power-line carrier telephony, developed by Bell Telephone Laboratories, makes it possible to transmit telephone conversations over rural electric distribution wires, and in numerous instances may prove to be the most practical and economical method of bringing telephone service to farm homes which are distant from existing telephone pole lines but close to electric power lines. By means of specially designed equipment a high frequency telephone current is made to pass onto and along the power line, and to leave that line at any selected pole, when it travels over a pair of telephone wires to the customer's telephone.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Hydrogen Peroxide for Propulsive Power

COMMENT BY COMMANDER H. A. ARNOLD, U. S. N.[1]

This concise and lucid paper[2] points out the high operational cost of hydrogen-peroxide power for propulsive power. For mobile applications its basic inefficiency from weight and space considerations leads to further disadvantages. For example, the Type 26 Walter submarine mentioned by the author was expected to sustain the 24 knots submerged speed for not more than 6 hr of a war patrol that might last some 90 days. For this, approximately 90 tons or 10 per cent of the surface displacement was devoted to H_2O_2 alone. (This of course omits consideration of the weight of the special Ingolin plant for which compensation was secured by reducing the standard means of propulsion.) Thus, assuming the Ingolin replaced pound for pound with Diesel fuel, the Type 26 submarine could have increased its maximum cruising radius by something in the order of 150 per cent

Owing to the difference in specific gravity of Ingolin and Diesel oil, the space occupied by Ingolin in the outside tanks of the German submarine would actually accommodate only about 56 tons of Diesel oil. However, another factor in submarine design, the necessity of maintaining sufficient variable tankage to keep neutral trim under all conditions of loading, makes it possible to increase this 56 tons to about 70 tons. As the author brings out, approximately one-quarter of the total weight of Ingolin used must be added to the submarine in the form of compensating or variable water. In the example chosen, nearly 22 tons of variable tankage should be reserved for compensating for the Ingolin. If the Ingolin load were to be replaced with Diesel oil, part of the space allotted to this 22 tons of compensating water could be added to the Diesel-oil tankage without disturbing the basic design. The remaining part would normally be required to compensate for the difference in weight between salt water and the additional Diesel oil, leaving space for a net gain of about 14 tons of Diesel oil. Thus, on a space basis, for equal submerged displacement, the cruising radius of the Type 26 German submarine could have been increased by about 116 per cent by replacing Ingolin with Diesel oil.

In submarine design, variable tankage is a necessary evil for the space so used is wasted in so far as furthering performance is concerned. Thus, any expendable fuel which differs in weight from sea water by a large amount is theoretically less desirable than one which differs by a small amount. Practically, it is usually better to have a fuel which weighs less than an equal amount of sea water, so that the normal loss in weight resulting from the use of other expendables (ammunition and provisions) will tend to be offset by the automatic fuel compensation.

Weight or space, and sometimes both, are important factors in nearly all types of mobile equipment. For fixed installations, high cost and the need for special precautions and material are likely to remain the outstanding disadvantages in the use of hydrogen peroxide.

Of course the Germans were well aware of the disadvantages of Ingolin. In their position they were justified in sacrificing economy, increased cruising radius, space, weight and almost anything else in order to achieve the outstanding standards of performance that Ingolin alone made possible. However, it does not necessarily follow that American industry, having time for investigation, should also accept the major disadvantages currently associated with the use of hydrogen peroxide for propulsive power.

COMMENT BY G. G. CREWSON[3] AND N. S. DAVIS, JR.[4]

The Germans, at the end of the war, had perfected processes for making peroxide in concentrations up to a maximum of 85 per cent. Two particular grades were standard with them, namely, Type Ts, an 82 per cent concentration of low total impurities, and Type Tss, an 85 per cent concentration containing as much as 800 ppm impurities, most of which were stabilizers added during the course of manufacture.

Both of these products were of a high order of stability and, on the average, could be expected to suffer an oxygen loss of not over 1 per cent in storage at ambient temperatures for 1 year.

In the meantime, in this country, there had been developed prior to the end of the war with Germany, a process for making a hydrogen peroxide of 90 per cent concentration and of a purity exceeding the best produced in Germany. Such peroxide also showed a high degree of stability although it contained no stabilizing compounds and obtained its stability from the purity of the product itself.

Various military agencies were actively studying the application of such a product during the latter months of and since the end of the war. Comprehensive studies of its properties and applications were made by the Chemical Warfare Service and were published in a series of three articles.[5]

The use of energy by direct decomposition of peroxide is of great importance when its availability in concentrated form can justify its cost. The peroxide may be readily and instantly decomposed to steam and oxygen by means of a permanent solid catalyst or a proportional flow of liquid catalyst. The heat of decomposition of 1 lb of 90 per cent peroxide is approximately 1110 Btu. The resultant products of decomposition would be 0.58 lb of water vapor and 0.42

[1] Naval Shipyard, Mare Island, Calif.

Opinions and assertations contained herein do not represent views of Navy Department.

[2] "Hydrogen Peroxide for Propulsive Power—Production and Use by the Germans During World War II," by Capt. Logan McKee, MECHANICAL ENGINEERING, vol. 68, 1946, pp. 1045–1048.

[3] Chief Engineer, Buffalo Electrochemical Company, Buffalo, N. Y. Mem. A.S.M.E.

[4] Chemical Engineer, Buffalo Electrochemical Company.

[5] "Chemical Propellants; Hydrogen Peroxide-Permanganate," by F. Bellinger, H. B. Friedman, W. H. Bauer, J. W. Eastes, J. H. Ladd, and J. E. Ross, *Industrial and Engineering Chemistry*, vol. 38, Feb., 1946, pp. 160–169.

"Chemical Propellants; Hydrogen Peroxide-Permanganate," by F. Bellinger, H. B. Friedman, W. H. Bauer, J. W. Eastes, and W. C. Bull, *Industrial and Engineering Chemistry*, vol. 38, March, 1946, pp. 310–320.

"Chemical Propellants; Hydrogen Peroxide-Permanganate," by F. Bellinger, H. B. Friedman, W. H. Bauer, J. W. Eastes, and S. M. Edmonds, *Industrial and Engineering Chemistry*, vol. 38, June, 1946, pp. 627–630.

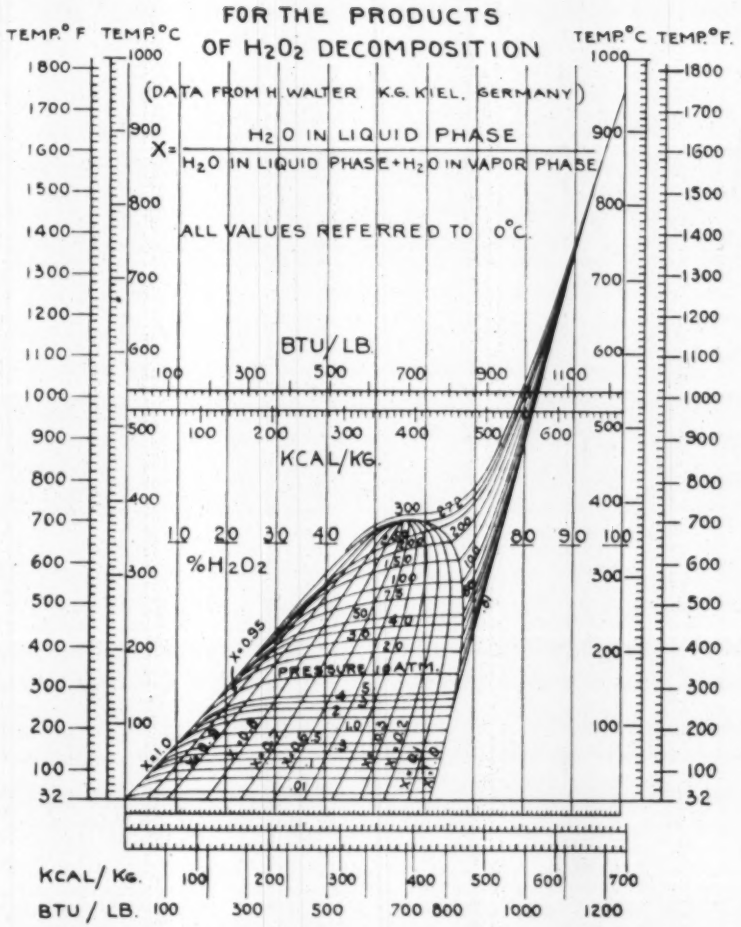


FIG. 1 HYDROGEN-PEROXIDE TEMPERATURE-ENTHALPY DIAGRAM

lb of oxygen at a temperature of 1340 F and atmospheric pressure, or 1380 F under 300-atm pressure. The enthalpy chart, Fig. 1 herewith, illustrates pressures and temperatures, as well as physical condition of vapors (saturated or superheated), resulting from decomposition of peroxides of various concentrations.

The freezing and melting points of hydrogen-peroxide solutions are shown in Fig. 2, the spread between freezing and melting points indicating the tendency toward supersaturation, as well as the variance in composition between the solid and liquid phases. Whereas 100 per cent hydrogen peroxide freezes at approximately 30 F, or essentially the same temperature as does water, any solution of peroxide and water freezes at a lower temperature, the minimum being approximately —67 F for solutions of 50–60 per cent concentration. A further point of interest in this respect is that on cooling any solution, represented by the right half of the curve, crystals are frozen out, which crystals have a peroxide content greater than that of the liquor, hence, the remaining liquor is

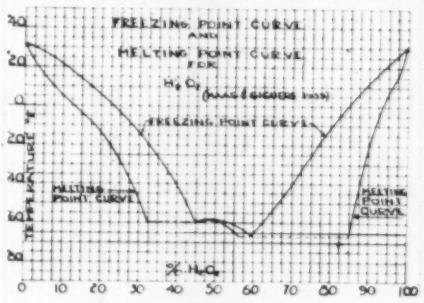


FIG. 2 FREEZING AND MELTING POINTS OF HYDROGEN-PEROXIDE SOLUTIONS

weakened in concentration and its freezing point correspondingly reduced.

Similarly, the solid phase, represented by the left half of the curve, is lower in peroxide content than is the liquor in equilibrium with it, and the formation of crystals therefore results in a more concentrated mother liquor. This being true, then, regardless of the strength of initial solution, the final solidification temperatures are those corresponding to the melting-point graph rather than the freezing-point graph, although solid particles will form in the liquid at points corresponding to the freezing-point graph. However, there is a great tendency for the liquid to supercool, and it is necessary to seed the solution with crystals of H_2O_2.

The solid phase of solutions in excess of 50 per cent concentration is more dense than the liquid phase; in other words, there is a contraction upon freezing rather than an expansion as with water.

Experience with American 90 per cent peroxide, does not confirm the German reports as to the initial higher rate of decomposition in storage. Many samples held in storage from 3 to 6 months have shown no measurable decomposition loss, and such loss as does occur in any period seems to be primarily a function of contamination before placing into storage or during the storage period. Very small amounts of stabilizers (5–10 ppm) are frequently added as a counteractant to such accidental contamination as may occur.

Emphasis is placed upon the point given by the author as to danger from spillage and the preventive measures. Peroxide of almost any concentration can and does cause fires if spilled on combustible material. At concentrations below 65 per cent, the entire heat of decomposition would be insufficient to evaporate the water; hence, excessive temperature rises would not be anticipated. However, since the vapor pressure of peroxide is less than that of water, natural evaporation from spillage will tend to concentrate it, and the contamination would be almost sure to give catalytic decomposition. Hence fires have resulted from spillage of even 27½ per cent peroxide. However, as mentioned by the author, an available supply of water for dilution of the strong peroxide, should accidental contamination result in temperature rise indicating decomposition or for flushing any spillage, is ample protection.

For handling and storing peroxide solutions, pure aluminum is the most adaptable material. Aluminum of 99.6 + per cent purity and copper-free is available and has proved to be thoroughly satisfactory. Pure tin is equally satisfactory but does not lend itself to fabrications as readily as does aluminum.

Where aluminum cannot be used, for structural reasons, and particularly where the time of contact is short, some types of stainless steel are satisfactory. Those proved to be so to date are Types 304, 309, 310, 316, 321, and 347. The use of such steels is of particular value where strength is required, as, for instance, in a pressure decomposition chamber.

Of the construction materials most

commonly used, copper and iron are the active decomposition catalysts. Others include platinum (a violent decomposition agent), lead, silver, and most organic substances. Natural rubber and most of the synthetic rubbers will not withstand the attack by peroxide. The polyvinyl-chloride rubbers are quite satisfactory and are in general use in contact with peroxide solutions. Others, such as polyethylene, etc., hold promise, and the entire field of synthetics and plastics is by no means fully investigated at this time. For the time being therefore only the polyvinyl-chloride materials are to be recommended for gaskets, packing, structural parts, or even as clothing when there is danger of coming into contact with concentrated peroxide solutions.

In all metal fabrications, whether of aluminum or stainless steel, the fabrication procedure is of importance equal to the selection of the construction materials. Aluminum is welded, using strips of the same metal (pure aluminum) as welding rod. Stainless-steel welds should be made with rods which will produce welds of the same character as the metal being used. All crevices must be avoided in the finished fabrication and welds should be ground smooth when it is possible. It is not the practice, now, to polish the inside of containers or equipment fabricated from aluminum or stainless steel, but all such equipment is carefully treated before peroxide is admitted to it. Such treatment consists of an alkali wash to remove any oil or grease from the surface, then, an acid treatment, using mineral acids to remove any incidental iron or copper and to passivate the metal surface. The containers are finally washed out with water having a high degree of purity.

In general, it may be said that the surface condition of a tank or other equipment for handling hydrogen peroxide improves with use, and retreatment is unnecessary where the article is in regular service.

At the end of the war, the Germans had discontinued the use of wax or other protective coatings and these are not used in this country. It is considered that the application of such coatings introduces as much hazard from contamination and flaking off as benefit by filling up the depressions in the metal.

The author mentions that the usual method of manufacture of H_2O_2 as a base product is the hydrolysis of persulphuric acid. It might be added "or the salts of persulphuric acid." Most of the German concentrated peroxide was the end product from the manufacture of peroxide from the ammonium and potassium salts of persulphuric acid. Ammonium and potassium sulphates in solution, with an excess of acid, were electrolyzed to the persulphates. These persulphate solutions were then steam-distilled, resulting in their hydrolysis to hydrogen peroxide and the sulphates. The sulphate solutions were then recycled through the batteries.

The hydrogen peroxide thus produced was at concentrations of from 25 to 35 per cent, depending upon the details of the process. To make their 80–85 per cent concentrations, a system of progressive distillations and rectifications was used. This system had a safe limit of about 85 per cent concentration in the final product.

In American practice, comparable base processes for the production of 25–35 per cent initial product are used and this is combined with continuous distillation, rectification, and purification steps, in such a manner that the higher concentration of 90 per cent can be reached safely, since the product progressively becomes more pure as its concentration is increased. It has been repeatedly demonstrated that the stability of the strong peroxides, hence safety in manufacturing and handling both during course of manufacture and as a final product, is dependent more upon its purity than upon any other factor.

It is also of interest that, independent of any knowledge of German practice, peroxide manufacturers in this country made more progress in one year, after being advised of its military value, in production methods of strong peroxides, than was accomplished by the Germans in 5 years of intensive development. It is thus safe to assume that in the application field, a comparable record is being made.

COMMENT BY N. C. JONES[6]

The author has given an excellent review of the properties and methods of safe handling of high-test hydrogen peroxide. As he has pointed out, high-test hydrogen peroxide is a dangerous chemical, but it can be and is handled safely when its properties are understood.

Hydrogen peroxide is stable when pure, and by pure is meant material containing far less than 1 ppm of those impurities which promote decomposition. Such impurities are a number of heavy metals of which copper, iron, chromium, manganese and lead are examples. There are some metals which are inert, such as pure aluminum and some special alloy steels.

There are substances like phosphoric acid, sodium phosphate, and sodium stannate which stabilize hydrogen peroxide in varying degrees. Their effect is to "tie up," so to speak, the decomposition catalysts by reducing their concentration to the vanishing point.

In practice, the cardinal principle in safe handling is to avoid contamination, but we must recognize that even with the most expert handling, contamination sufficient to promote instability is liable to occur. For that reason, all commercial products contain some amount of stabilizer.

Since, in general, stabilizers counteract or nullify decomposition catalysts, it follows that the catalysts used to make steam and oxygen from hydrogen peroxide in an engine such as the author has described, will likely be poisoned by the stabilizer. The problem is one of finding a happy medium. In general, it may be said that one should have as much and as effective a stabilizer present as the end use will stand, simply to make the hydrogen peroxide as safe to handle as possible.

It still remains to be determined in many cases what kind and how much stabilizer is permitted to give satisfactory engine performance.

[6] E. I. du Pont de Nemours & Company, Wilmington, Del.

Gas-Turbine Cycles

COMMENT BY G. M. DUSINBERRE[7]

Discussion of this paper[8] indicated to the writer the need of a nomenclature for this type of compression, and a qualitative and quantitative account of the ideal limiting process to be taken as a standard.

Mechanical engineers are well acquainted with the reversible adiabatic process with a dry gas. The corresponding process with a gas-vapor-liquid mixture is less familiar to us, but the meterologists have long had to consider it. They give it the name of "wet adiabatic," and we can well follow this terminology.

As the author points out, the ideal limiting case is when the gas-vapor mixture is in equilibrium with the liquid present. Thus, we are concerned with saturated air up to the point where all

[7] Department of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. Mem. A.S.M.E.

[8] "Value of Wet Compression in Gas-Turbine Cycles," by R. V. Kleinschmidt, MECHANICAL ENGINEERING, vol. 69, 1947, pp. 115–116.

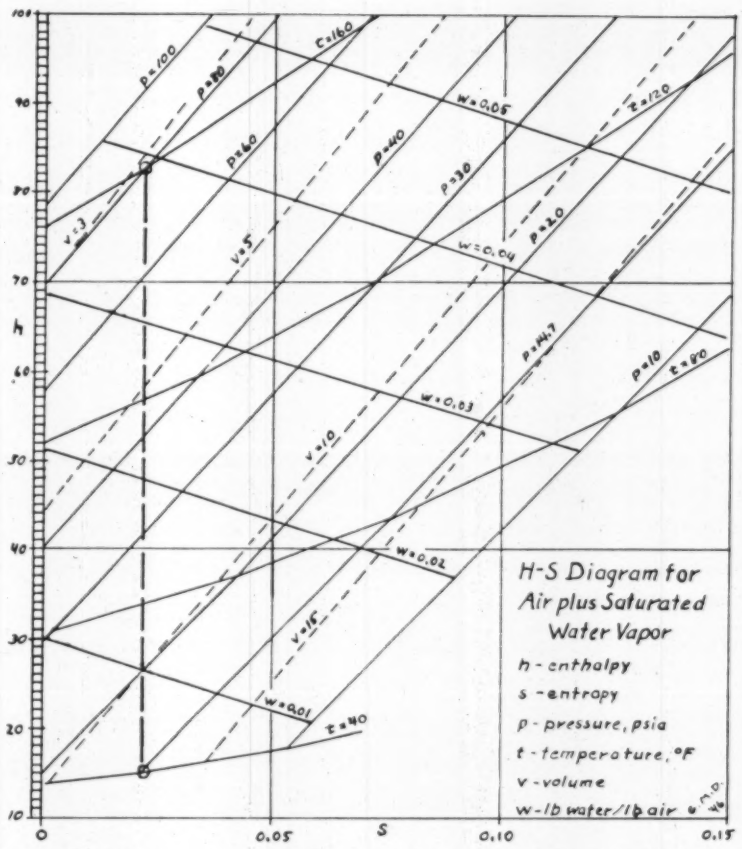


FIG. 1 CHART SHOWING LIMITED RANGE OF EQUILIBRIUM STATES OF AIR MIXED WITH SATURATED WATER VAPOR

water injected has been evaporated. Beyond this point, compression follows the ordinary laws for mixtures and offers no difficulty.

For this "wet" phase of compression, the relations are rather complex owing to the varying properties of water. However, as is often the case, trial-and-error solutions can be avoided by the use of a chart. The writer has prepared Fig. 1 of this comment, to show a limited range of equilibrium states of air mixed with saturated water vapor.

The chart is on the usual psychrometric basis, in that the properties of the mixture are referred to 1 lb of dry air. Total pressures are shown. For generality, it is necessary to ignore the volume, enthalpy, and entropy of the liquid present. The error from this cause should not usually be important; if it becomes so, the chart will afford a good start toward the trial solution.

An example will illustrate the use of the chart, and at the same time verify in detail the author's statement of the advantages of the system.

Example: Given 1 lb of bone-dry air at 62.6 F and 14.7 psia, to be compressed to 80 psia.

(*a*) Find the final temperature, volume, and work of compression for reversible "dry" adiabatic compression.

(*b*) Find the same items for reversible "wet" adiabatic compression.

(*c*) Find the per cent saving in work.

(*d*) Find the weight of water required.

Solution: (*a*) Assuming $cp = 0.24$ and $k = 1.4$, we find

Temperature, deg F.....	398
Volume, cu ft per lb.....	3.96
Work, Btu per lb.....	78.0

(*b*) We assume the air to become saturated before the beginning of compression, and to remain so throughout. A standard psychrometric chart shows the temperature of adiabatic saturation to be 40 F. We enter the chart at 40 F and 14.7 psia, where $h = 15.2$ Btu per lb. Then follow an isentropic to 80 psia, as shown by the heavy broken line. Here we find

Temperature, deg F.....	160
Volume, cu ft per lb.....	3.05
Enthalpy, Btu per lb....	82.6
Work, Btu per lb.....	67.4

(*c*) The per cent saving is (78.0–67.4)/78.0 = 13.6 per cent.

(*d*) At the same point on the chart, we find $w = 0.039$ lb per lb, which is the weight of water to be added, the air being initially dry. If a less amount of water were used, the chart would be valid only to the corresponding humidity line. The remainder of the pressure rise should then be calculated as "dry" compression for the mixture existing at that point.

The Technical Man's Cause

TO THE EDITOR:

At the risk of extending discussion beyond the point of interest, I refer to Mr. K. P. Keefer's letter in reference to the technical man's cause,[9] and the comment[10] thereon by Mr. E. Morgen of East Melbourne, Australia.

Mr. Morgen's comments present the approach of the medical profession and its established practice as a comparator for publicity development for the engineering profession. Are these two professions even remotely related in their functions to society whereby the methods of one may be applied to the other? Examination will disclose few obvious analogies. Outside of public health, epidemiology, and related broad subject considerations, the physician or surgeon is concerned mainly with the individual. Even here, emphasis does not extend, in the minds of the public, to the particular organ or malady requiring attention but is directed to constructive correction. The value of services rendered are to the individual as a component of society. The service of the engineer is rendered to society, thereby benefiting all components.

The broad function of the engineer is the assumption of his portion of the division of labor which makes possible our modern civilization. The relative importance of his contribution is not recognized or appreciated by the general public, but that is understandable if current economy is considered. Most everyone is concerned with results, engineers included; and outside of their own sphere of activity, give slight consideration to the methods by which they are achieved. That engineering is essential to accomplishment of the result is submerged by the importance of the result. The decisive factor is its value in human progress.

How then can the engineer secure recognition for his contribution and labor? The derivation of such a formula is not easy but the points on the curve have been

[9] "The Technical Man's Cause Is Not Hopeless," MECHANICAL ENGINEERING, vol. 68, 1946, p. 1085.

[10] Same title, Discussion, MECHANICAL ENGINEERING, vol. 69, 1947, p. 514.

rather accurately located by long experience and observation. These are adaptability, perspective, and application. Their position on the curve will be determined by the constant of education and training, and the slope of the curve will respond to the exponent of hard work. There is no shortcut publicity stunt whereby the engineer may achieve certain universal recognition as an outstanding component of society. He must do so by the process of constructive effort and the maintenance of high professional standards. This, and his individual and collective acceptance and discharge of responsibilities as an informed and active citizen beyond the scope of remunerative duties, will assure achievement of that objective.

L. H. GARDNER.[11]

Manufacturing Pencils

COMMENT BY S. B. SEELEY[12]

To those who have unsuccessfully searched literature for the details of pencil manufacture, it will be obvious that this paper[13] has in it the element of pioneering. Since there is so little published on this subject, it is to be expected that the paper would be somewhat general and descriptive. However, it differs from others in that all steps of manufacture are faithfully reviewed in a technical manner and in that tolerance specifications are given.

The engineer engaged with those products customarily associated with the Wood Industries Division of the Society may be interested to know that here are precisions and tolerances of the order maintained by many metalworking industries.

It will be noted that the English and metric systems are used simultaneously, as is done in younger industries (who has not bought 50-ft reels of 16-mm film?) It may be added that the cumbersome and misleading drill-gage system is customarily used in addition to the other two, thus adding unnecessarily to the confusion. Tie up these three systems of mensuration to the fact that pencils are counted by gross rather than by decimals, and one gets an idea of the simplicity of record-keeping.

Unless the good start made by the author is to die, other papers on the wood-cased pencil should be forthcoming from the industry. Appropriate and timely subjects are suggested as follows: "The Selection and Preparation of Wood for Pencil Manufacture," "The Adhesion Problems of Wood-Cased Pencils," "Shaping Methods of the Pencil Industry," "Materials Handling Methods in Pencil Manufacturing," "The Finishing and Decorating of Pencils." Without such encouragement, it is inevitable that technical literature on wood-cased pencils will lie dormant. It is hoped that a large industry which has developed such high precision in woodworking can meet this challenge.

[11] Consulting Engineer, Baltimore, Md. Mem. A.S.M.E.

[12] Director, Research and Technical Division, Joseph Dixon Crucible Company, Jersey City, N. J.

[13] "The Manufacture of Wood-Cased Pencils," by C. R. Nichols, Jr., MECHANICAL ENGINEERING, vol. 68, 1946, pp. 956–960.

Industrial Relations

TO THE EDITOR:

The writer heartily agrees with Mr. Nickerson's statement in the April issue,[14] that "more than generalities and lip service are necessary." Unfortunately, no facts and figures, no detailed analysis, were present in his discussion. For example, the fact that the present retail trade in the United States is about $100 billion dollars per year would have had some bearing upon his comment that productivity should be increased. The fact that the income of the average American family is less than $45 per week should have been considered in connection with Mr. Nickerson's statement that "unless productivity keeps up with wages, unless labor costs stop their upward ascent, then industrial profits will disappear. . . . ." If Mr. Nickerson had bolstered his arguments with data on the present profits of industry as compared with the rate of savings of the wage earner, the writer would feel less skeptical. If he had differentiated between actual shortages and artificial scarcities, there would be less cause for comment.

The engineer is trained to apply calm and objective thinking in the analysis of technical problems. It is this kind of thinking that is responsible for the successful development of science and technology. Why, then, does the engineer fail to apply this same kind of thinking to social and economic problems? Why does he permit his emotions and prejudices to intrude upon his objective analysis? Why does he permit himself to resort to the use of stereotyped terms, instead of carefully defining his terms?

Mr. Nickerson states, "it is foolish to blind ourselves to the fact that the communists are making an effort to wipe out profits by forcing wages up and productivity down." The word "communist" in this case appears to carry an emotional rather than objective meaning. What evidence is there to sustain Mr. Nickerson's contention? On the contrary, the evidence indicates that there is an ever-increasing margin between rising prices and wages, and that production is increasing apace. Only out of a depression can the threat of a collectivist ownership arise. It is true that depression may result from the failure of industry to make a reasonable margin of profit, but this usually occurs when the consumer is unable to pay the price that industry asks for its products. Depression is invited when wages drop and men are laid off, for industry cannot then sell its products no matter how much it produces. It seems to me that the danger of depression and the subsequent threat of collectivist ownership therefore can be averted by keeping wages (that is, purchasing power) at a high level. What, then, is Mr. Nickerson's basis for sticking the communist label to those who advocate that an equitable ratio be maintained between the amount of goods that the wage earner consumes and the amount that he produces?

The writer may be mistaken, but it seems to him that the science of economics is being oversimplified. Productivity and purchasing power are but two factors in an extremely complex equation. A complete objective analysis of the problem would probably put to shame the stress analysis of a skyscraper. If we wish to use the laws of economics as a basis for our arguments, we must learn to take into account the limitations of those laws, just as we have learned to do with physical laws. The individual laws of economics are not all-pervading, nor do they operate in a vacuum. Many laws are operating simultaneously. We must learn to determine which factor in this complex equation predominates over the others under a given set of conditions. The time has come for a sober analysis of principles and a rigorous definition of terms. To distort or ignore the facts in order to sustain our beliefs, to misconstrue the principles in order to "prove" a preconceived conclusion, will accomplish nothing constructive, but will only add to the confusion in this very confused world.

The burden of social responsibility is falling with ever-increasing concentration upon the engineer. That responsibility increases in direct proportion to the influence which technology exerts over society. We have spoken much of the professional status of the engineer, but we are wholly unworthy of that status until we meet our responsibilities squarely and unselfishly. We cannot afford to permit our emotions

[14] Comment by J. W. Nickerson, MECHANICAL ENGINEERING, vol. 69, 1947, pp. 327–328, on paper, "Engineers and Industrial Relations," by C. A. Myers, MECHANICAL ENGINEERING, vol. 68, 1946, pp. 1059–1060.

and prejudices to becloud our thinking. When we succeed in applying the same kind of thinking to economic and social problems that we have been trained to apply to technological problems, we will close the menacing chasm that exists between the progress of humanity and the progress of machines.

PETER BERGER.[15]

COMMENT BY J. W. NICKERSON[16]

The statement referred to by Mr. Berger was a short introduction to Mr. C. A. Myers' paper.

It brought out the incontrovertible fact that if hourly wages continue to increase more rapidly than hourly production, then labor cost, which equals wages divided by production, will continue to increase.

The Bureau of Labor Statistics tells us that productivity in manufacturing industries increased 125 per cent between world wars. During the same period, unit labor costs dropped 44 per cent and wholesale prices of manufactured goods dropped 38 per cent.

On the other hand since World War II, hourly earnings have so far outdistanced productivity that it is conservative to say that our over-all labor cost has increased 40 per cent. It is this condition which has made it seem necessary for prices to rise to prevent the disruption of our individual enterprise system.

The fact that some prices and some profits have increased unwisely and inordinately does not in any way affect the clear-cut fact that our standard of living and our very liberties are threatened if the wages paid for production continues to increase at a rate greater than the rate of production itself.

It is entirely unnecessary to submit proof that the "Communist Party is making every effort to wipe out profits by forcing wages up and productivity down."[17] He who reads may know that the primary purpose of the Party and its partisans is to wreck the American Individual Enterprise System. They and their friends realize there is no better way to accomplish this purpose than to force wages up at the expense of productivity.

The efforts which have been and are being made in this direction need to be met and mastered. Both labor and management need to realize that our future prosperity depends largely on constructive ideas; on technological improvement. Methods need to be worked out and can be worked out whereby labor itself can immediately participate in the labor savings which result from such progress.

The same kind of courage, confidence, and trust is called for which is now being manifested by those manufacturers who are reducing prices when there is no competitive reason for doing so. However, we must not have a static and stagnant industrial economy. America's standard of living has been based on progress and must so continue. This means continually high productivity and earnings, continually lower costs and prices, continually satisfactory return on investments, and continually greater employment and stability.

[15] Los Angeles, Calif. Jun. A.S.M.E.

[16] Director of Industrial Relations, Bigelow, Kent, Willard & Company, Boston, Mass. Mem. A.S.M.E.

[17] This was the original wording of Mr. Nickerson's letter. Owing to an unfortunate substitution the sentence was printed as Mr Berger quoted it, with "communists" instead of "Communist Party."—THE EDITOR.

David Parker Godwin

TO THE EDITOR:

David Parker Godwin, head of the Forest Service Division of Fire Control under the U. S. Forest Service, lost his life in an airplane accident in West Virginia on June 13, 1947.

He was returning to Washington from a meeting at Madison, Wisconsin, of the Joint A.S.M.E.-S.A.F. Committee on Forest Protection, of which he was co-chairman, which proved to be his last official conference. He expressed himself to the undersigned as well satisfied with the accomplishments at this meeting, and remarked that he thought the joint committee had now outlined a most constructive program of co-operation.

Mr. Godwin was born in Norfolk, Va., on July 24, 1887, was educated at Army General Staff College and the Army School of the Line. He entered the Forest Service about 1912 as a forest guard in California. He became a captain in the 1st Engineers in World War I. After two years' service overseas he returned and engaged in private business at New York City until 1935, when he re-entered the Forest Service as assistant chief of Fire Control. He was promoted in December, 1946, to the position he held at his death. He has made an enviable record in improving the fire-defense methods of the Forest Service and was an outstanding example of business efficiency in government service.

He leaves a wife, who under the pen name of Thelma Strabel is an author of note in her own right, and also a sister, Mrs. Nelson M. Beach, Hadlyme, Conn., and a brother Harold O. Godwin, U. S. Army, stationed in California.

THOMAS D. PERRY.[18]

[18] Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with Committee Secretary, A.S.M.E., 29 W. 39th St., New York 18, N. Y.

The procedure of the Committee in handling the Cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval and then issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of May 9, 1947, and approved by the Council on June 26, 1947.

CASE NO. 1034 (*Annulled*)

CASE NO. 1048

(*Interpretation of Par. P-294*)

Inquiry: What is the minimum size of gage cock connections for use in power boilers?

Reply: It is the opinion of the Committee that the connections of gage cocks for power boilers should be not less than is required for similar connections for a gage glass, namely, $\frac{1}{2}$ in. pipe size.

CASE NO. 1049

(*Interpretation of Par. P-242*)

Inquiry: When plain horizontal Adamson type flues are made in sections not less than 18 in. in length and not less than $\frac{5}{16}$ in. in thickness, may welded circumferential double butt seams be used?

Reply: When plain Adamson type flues are made in sections not less than 18 in. in length and not less than $\frac{5}{16}$ in. in thickness, circumferential seams may be double-butt-welded. The welding in such seams shall comply with the requirements of the last section of Par. P-242(3).

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Engineer in Society

THE ENGINEER IN SOCIETY. By John Mills. D. Van Nostrand Co., Inc. New York, N. Y., 1946. Cloth 1/2 × 8 1/4 in., 196 pp., $2.50.

THIS book by an engineer for engineers is in effect a self-analysis of the engineering profession. It reports the observations and comments of an engineer whose 45 years of engineering practice range across many by-ways of the profession—university teaching, research work, personnel work connected with recruiting engineers and scientists for technical staffs, and, finally, editorial work.

With an interest in men as well as in science, John Mills has picked up along the course of his career convictions and ideas which he reports in his book "The Engineer in Society." Coming at a time when engineers are concerned with economic status and organization of the engineering profession, Mr. Mills' book is stimulating and provocative.

Engineers are the hope of the world, he says, because they are the custodians of the "scientific method." This he defines as "the idea of extending knowledge by quantitative experiments under controlled conditions where only one fact is allowed to vary at a time so that the experimenter can say: Other things being equal, *X* varies with *A* in a specified quantitative manner."

Because advance in the art of human relations is a slow evolutionary process, engineers can best help society by helping themselves to determine their rightful place in it. As the first step, in an evolutionary course of action, the author suggests that engineers and scientists conduct "engineering study of their class relationship to society," the first object of which should be a study of the "scheme under which they receive their rewards, in other words, their pay."

This is the theme of the book, but in developing it Mr. Mills has much to say about engineering aptitudes, the practice of business which takes engineers away from creative work by making administrators of them, and about the alleged collusion of employers in determining compensation of engineers.

When Mr. Mills suggests that "scientific workers in industry should organize," he is careful to state that they should not "be organized," and he dispels the idea of a labor union such as conceived by C.I.O. or A.F.L. organizers. Except in a negative sense his proposed organization is a vague unified effort finding its leadership and inspiration somewhere within the engineering profession. Such leadership he says, "does not seem to be in the purview of the existing technical societies, engineering or scientific," because these organizations are not "adapted to the purpose and investigations which I am advocating."

For his lack of faith in the Founder Societies, Mr. Mills gives two reasons, first because they are "eminently safe, sound, and conservative" in matters of professional interests," and second, because they are "dominated by vested interests." To sustain these accusations, the author offers not an array of documentary evidence, but only isolated incidents of his experience on engineering society committees.

Mr. Mills may have good reasons for his criticism of the Founder Societies, but it is to be regretted that he expresses them without more adequate substantiation. When he talks of incipient executives in engineering ranks who, in climbing the ladder of success, knock dust into the eyes of those below, he introduces a note of bitterness which detracts from some of what he has to say.

For all its tantalizing generalities, Mr. Mills has written a book which is bound to stimulate those engineers who are concerned by the state of the profession. It may well stimulate others, as admirably qualified by experience as himself, to emulate his example. The profession needs books by its elder statesmen which aim to explain the forces which motivate it and to define the objectives it should pursue.—A. F. B.

Books Received in Library

ELECTRIC CONTACTS. By R. Holm. Almqvist & Wiksells Akademiska Handböcker, Hugo Gebers Förlag, Stockholm, Sweden, 1946. Cloth, 6 × 9 1/2 in., 398 pp., illus., diagrams, charts, tables, 45 Sw. crowns; about 62s. This book presents a detailed study of the physical principles of contact phenomena, including all fundamental formulas, with a large amount of tabular and graphic data. The three main parts deal respectively with stationary contacts, sliding contacts, and electric phenomena in switching contacts. In the section on sliding contacts considerable space is devoted to the question of mechanical friction and wear. The description of circuit-breaker phenomena is limited chiefly to weak currents. There is a twenty-five page bibliography.

NAVAL MACHINERY, 1946. 2 volumes. United States Naval Academy, Annapolis, Md. Published by United States Naval Institute, Annapolis, Md. Cloth, 8 1/4 × 11 in., paged in sections, illus., diagrams, charts, tables; vol. 1, $4, vol. 2, $4.25. This 2-volume work, presented as a descriptive treatment of steam engines and machinery to be found aboard ships of the Navy, emphasizes construction details and operating principles. The material is grouped into four parts: Parts 1 and 2, naval boilers and naval steam turbines, are in one volume; Parts 3 and 4, naval auxiliary machinery and naval reciprocating steam engines, are in the other. The detailed index which appears in both volumes covers all four parts. Twenty one large, folded plates, relating only to parts 1 and 2 are bound in at the back of that volume, adding to the wealth of illustrative diagrams which accompany the text.

RADIANT HEATING. By T. N. Adlam. Industrial Press, New York, N. Y., 1947. Fabrikoid, 6 × 9 1/4 in., 472 pp., illus., diagrams, charts, tables, $6. This practical treatise covers American and European practice in the design and installation of systems for radiant or panel heating, snow melting, and radiant cooling. While the theoretical aspects are effectively dealt with, the emphasis is on the application to actual problems, with factual, step-by-step demonstrations of practical procedure. The final chapter contains 64 charts for the direct determination of pipe size and spacing necessary, and covering iron or steel pipe and copper tubing.

STANDARD COSTS for MANUFACTURING. By S. B. Henrici. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × 9 1/4 in., 289 pp., diagrams, charts, tables, $3.50. This textbook presents a step-by-step description of the way in which standard-cost techniques are used for controlling manufacturing expense, and for simplifying cost-accounting procedures. It outlines the theory and practice of standard-cost accounting, covering the setting up of accounts, developing the standard-cost system; setting standards for direct and indirect labor, materials, maintenance, fuel and power, and general overhead. It also shows how standard costs can be used to develop operating budgets and supervisory incentive plans.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

COMPILED AND EDITED BY A. F. BOCHENEK

Careful Planning Results in Excellent 1947 A.S.M.E. Semi-Annual Meeting at Chicago, Ill., June 15-19

IMAGINATIVE planning and hard work on the part of the local committees combined with an excellent and varied technical program under the auspices of the professional divisions and the Meetings Committee resulted in an enjoyable and fruitful program for 1500 members and guests at the 1947 Semi-Annual Meeting of The American Society of Mechanical Engineers, which was held at the Stevens Hotel, Chicago, Ill., June 15-19, 1947.

Although the technical program did not get under way until Monday morning, the Regional Delegates Conference commenced its important sessions on Saturday, June 14, and the Executive Committee of the Council and the Council itself met on Sunday, June 15. The social program also started on Sunday, with an automobile drive along the lakefront, ending at the Michigan Shores Club in Wilmette, where dinner was served and entertainment provided. Numerous committee meetings were also held during the course of the week, and on the afternoons of Monday, Tuesday, and Wednesday, members and guests had the opportunity to enjoy several inspection trips to some of Chicago's industries and research laboratories. A special program was provided for the women.

President O'Brien Speaks at Luncheon

An interesting series of luncheons and dinners began on Monday noon with the President's General Luncheon, at which John R. Michel, chairman of the Chicago General Committee, presided, and the official greetings of the City of Chicago were extended, on behalf of the Mayor, by Loran DeLancey Gayton, member A.S.M.E., assistant city engineer of the City of Chicago.

The principal speaker at the luncheon was Eugene W. O'Brien, president A.S.M.E., whose subject, "Broader Vistas," dealt with the work of the Engineers Joint Council.

Issuing the first public report on the work of this Council in national labor legislation, through a labor panel set up by the five member societies and the National Society of Professional Engineers, President O'Brien said:

"This panel set up a program and succeeded in getting into the legislation its principal objectives: that engineers should have freedom of choice in accepting or rejecting collective bargaining; that they should not be arbitrarily included with employees of nonprofessional grade, as is true of existing unionization of engineers under the Wagner Act; that if collective bargaining is the proper procedure, engineers should have the right to organize their own professional bargaining unit; and that the engineer, being a professional man, should retain the right of individually approaching management in negotiation of employment conditions."

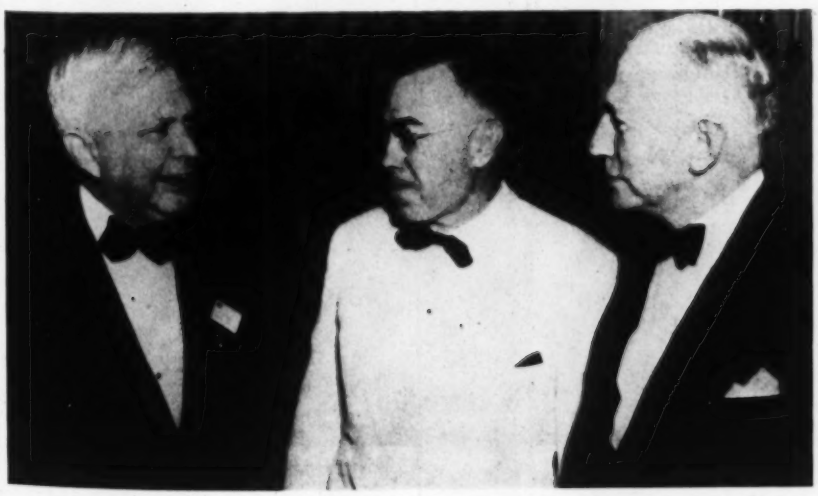
The American Society of Mechanical Engineers and the American Institute of Electrical Engineers, both represented on the Engineers Joint Council, sent out questionnaires to their members, President O'Brien reported.

The A.I.E.E. submitted one question to its 31,000 members and student members: "Do you favor exempting professional employees from the provision of the National Labor Relations Act?" More than 18,600, or 60 per cent, replied. Of these, 84 per cent favored exclusion; 16 per cent were opposed to exclusion.

The A.S.M.E. circularized its 21,000 members on this question and returns from the first 10,245 were as follows: 76 per cent were in favor of exempting engineers; 24 per cent were against it. A second question was added which asked how many were in favor of exclusion of engineers from a new law with the specific safeguards indicated. The answer was still "no," for 54 per cent were opposed and 46 per cent were in favor. All answers were broken down by age groups and different engineering levels. Mr. O'Brien stated the following conclusions:

"It seems reasonable to conclude that you feel overwhelmingly against the present Wagner Act—that 75 per cent of you want complete exclusion from similar national legislation, but that a substantial minority, made up largely of younger men, prefer to retain the right to bargain collectively, providing it can be done with the proper safeguards, and of their own choice and in their own fashion."

"Junior members and student members," he said, "feel that they need protection, need some



Left to right: CHARLES E. WILSON, PRESIDENT, GENERAL MOTORS CORPORATION; EUGENE W. O'BRIEN, PRESIDENT A.S.M.E., AND ALEX D. BAILEY, FELLOW AND PAST-PRESIDENT A.S.M.E., CONVERSING AT THE BANQUET ON JUNE 18.

one who is persuasive and articulate to represent them with management—that they haven't too much confidence in management, with plenty of instances of poor management to point to as reason enough for this attitude.

"I believe that much of their attitude and opinion are exaggerated; that what they need more than anything else is a friendly professional orientation in their adopted field of work."

On the general subject of co-operation through the Engineers Joint Council, Mr. O'Brien declared:

"It is doing a fine job for these young engineers, a better job than any group of older engineers has ever done in the past. . . It is doing the sort of work I have always envisioned as being done one of these days by an over-all engineering society responsible and responsive directly to individual members."

President O'Brien cited responses of the A.S.M.E. members to a progress report of the Society's Engineers Joint Council activities. Many suggestions for further projects were received, among them: Pushing patent protection; reviewing the curricula of engineering schools; promoting highway safety; combatting race prejudice; publication of a technical dictionary; promoting employment opportunities for GI's; a survey of economic and technical opportunities in South America; working out engineering aptitude tests; preservation of national resources; improving the mining and delivery of coal, curing periodic depressions.

He characterized these as "most of them pertinent, some just a bit far-fetched." The most common comment was, he said, that "Engineers Joint Council merely reflects a long-standing need of concerted action in the profession, of unification of engineers and of engineering societies."

Charles E. Wilson Speaks at Dinner

At the general dinner held in the Grand Ballroom of the Stevens Hotel on Monday night, Alex D. Bailey, past-president A.S.M.E., presided. The musical program was provided by Johnny Jones and his orchestra, and by Miss Margery Lundquist, coloratura soprano, who was accompanied at the piano

L. J. FLETCHER RECEIVES CONGRATULATIONS AFTER HIS TALK AT THE CITIZENSHIP LUNCHEON ON TUESDAY

by her mother, Mrs. Arthur J. Lundquist. Miss Lundquist's father is a member of the A.S.M.E. Chicago Section.

Charles E. Wilson, president, General Motors Corporation, Detroit, Mich., delivered the address. His subject was "The Great Delusion—Where Marx Went Wrong." Mr. Wilson's address was an exposé of the fallacies of Marxism and the complete text will be found on pages 658–660 of this issue.

Citizenship Luncheon

The Tuesday luncheon was devoted to the subject of better citizenship. F. A. Faville, president, Faville-Le Vally Corporation, Chicago, presided, and Leonard J. Fletcher, director of Training and Community Relations Caterpillar Tractor Company, Peoria, Ill., spoke on the influence of A.S.M.E. Sections in public activity.

Mr. Fletcher made a fervent plea for greater attention to the preservation of the American way of life by all citizens and particularly by engineers. He recalled briefly some of his observations in Soviet Russia where he had seen at firsthand the conditions under which engineers were compelled to work. He warned his audience that World War III was already in progress and that it was taking the form of a revolution with a communistic society as its objective. He implored his audience to sacrifice time spent at golf and bridge so that they could devote more of their energies to combatting the growth of communism, and threw out to A.S.M.E. sections and all A.S.M.E. members a challenge to exert their utmost in preserving democracy as we have known it. Mr. Fletcher's speech was delivered extemporaneously but, as it was recorded, a version of it is being prepared by Mr. Fletcher for publication at a later date.

J. D. Cunningham Presides at Banquet

The semi-annual banquet of the A.S.M.E. was held Wednesday evening, June 18, and was attended by approximately 450 members and guests.

James D. Cunningham, Fellow A.S.M.E., president, Republic Flow Meters Company, Chicago, Ill., as toastmaster, introduced the members seated at the speakers' table. He then introduced President O'Brien who presented a "fifty-year" gold button to James H. Herron, Fellow and past-president A.S.M.E., president, James H. Herron Company, Cleveland, Ohio. Fifty-year buttons were also on hand for James T. Faig, Fellow A.S.M.E., president of departments, Ohio Mechanics Institute, and Charles H. Morse, member A.S.M.E., retired; unfortunately they were unable to attend.

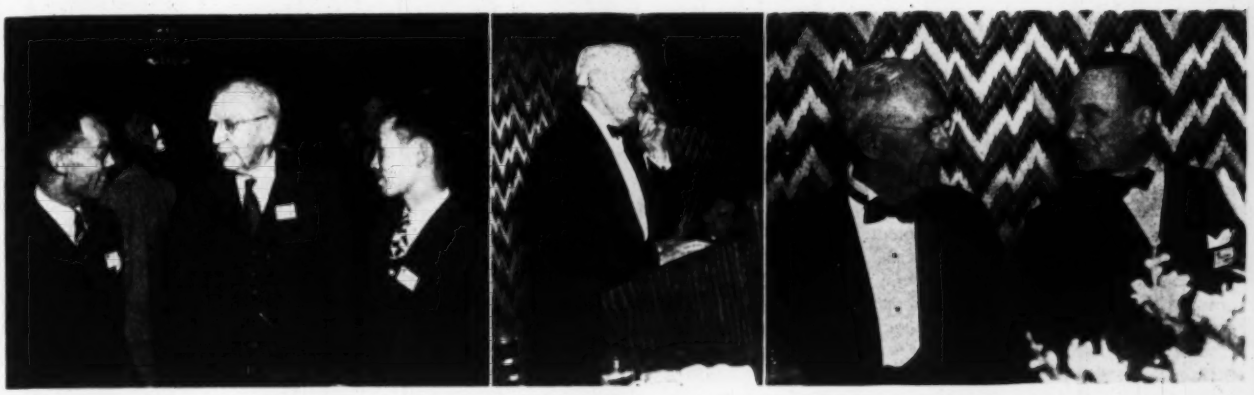
Charles B. Burdick, representing the A.S.C.E., then presented the Alfred Noble Prize to Martin Goland, junior A.S.M.E., Midwest Research Institute, Kansas City, Mo., for his paper, "The Flutter of a Uniform Cantilever Wing." The Alfred Noble prize certificate and cash award is given annually to a member of one of the four Founder Societies or the Western Society of Engineers, under 30 years of age, for a paper of merit. The prize fund was set up by the late Alfred Noble, president both of the Western Society of Engineers and the American Society of Civil Engineers, the latter society administering the prize. Mr. Goland also holds the A.S.M.E. Junior Award and the Spirit of St. Louis Medal.

N.A.M. Officer Delivers Address

The speaker of the evening, Robert R. Wason, chairman of the board, National As-

AT THE BANQUET

(*Left to right:* Martin Goland, junior A.S.M.E., chairman, Engineering Mechanics Research, Midwest Research Institute, Kansas City, Mo., winner of this year's Alfred Noble prize; and J. Calvin Brown, vice-president, A.S.M.E., owner, firm of J. Calvin Brown, Los Angeles, Calif; Robert R. Wason, president, Manning, Maxwell, and Moore, Inc., and chairman of the board, The National Association of Manufacturers, New York, N. Y., principal speaker at banquet; Col. L. F. Grant, president, The Engineering Institute of Canada, and R. E. Ballester, Calvin W. Rice lecturer.)



AT THE BANQUET, WEDNESDAY, JUNE 18

[*Left to right:* James Chi Ma, James M. Herron, and Ting Hwa Chien (Messrs. Ma and Chien are attending Iowa State College, Ames, Iowa, on John R. Freeman scholarships); Mr. Herron, a fellow and past-president A.S.M.E., president, J. H. Herron Company, Cleveland, Ohio, received a gold button for 50-year membership in the A.S.M.E.; James D. Cunningham, fellow A.S.M.E., president, Republic Flow Meters Company, Chicago, Ill., toastmaster at Semi-Annual banquet; Oscar A. Leutwiler, T. S. McEwan, vice-president, A.S.M.E. Region VI.]

sociation of Manufacturers, and president, Manning, Maxwell, & Moore, Inc., spoke on the subject "Engineering Waits for Economics," in which he issued a warning against accompanying the American billions to aid Europe with economic controls that would choke production.

"Unless we export the competitive system of America as well as the products of America, we cannot rescue Europe nor save ourselves," Mr. Wason said. "Secretary Marshall's suggestion that the European nations get together on plans for self-aid is good. It would be equally desirable for the American Government to arrange for the export of the competitive-enterprise system that made America, instead of the export of our products with the re-export of socialistic doctrines that may well keep the European peoples in poverty. Europe needs more drafting boards and fewer boards of inquiry—more slide rules and fewer top hats.

"Before America embarks on its campaign to rescue the authoritarian states of Europe it should reduce and abolish authoritarian controls in America. It should return to the people the right to spend more of their own money. It should abandon the teaching of communism in schools. It should quit choking venture capital that alone makes jobs. It should stop raising the costs of food, wages, and taxes which give us an inflationary spiral of prices. It should quit deflating employment and jobs by its attack on profits and its limitation on investments.

"Plans are afoot to buy peace in Europe at the cost of taxpayers in America. Nine billion has already been spent. Four billion is now authorized. Five to six billion per annum for several years is contemplated.

"America is confused by the enemies here at home who would help only their comrades abroad. Our help is limited by absorption in 14 years of communistic laws that most Americans now believe should be prevented from expansion in Europe. Our government attempts to differentiate between fascism, socialism, and communism. All three are the product of Karl Marx. All three increase the power of the state and reduce the liberties of the people.

"The government would give our produced goods to Greece and Turkey, and would provide at the same time communist economic controls that would limit the production of their own goods, which they seek to achieve.

"Even now, 60 million German people and 40 million Italians are prevented from earning their own livelihoods by regulations that keep them in servitude at the expense of the American people. German and Italian farmers resist the occupational controls that take their crops and produce to feed millions kept idle by occupational armies, just as American farmers refused to account for eggs under O.P.A. controls.

"America cannot help Europe by exporting our dollars. Every nation has more money than it can use because goods cannot be bought. Therefore America must export our production methods which alone can make valid the European monies issued.

"Before 20 billion more dollars are sent to Europe, the American people should ask: Can we supply the money and remain solvent? What will the dollars buy if we send them? What relief will they give? Will 20 billion buy peace or war? Will it make the peoples of Europe independent and self-sustaining, or only more dependent on the United States?

"The American people should have the full answers to these questions from the President, from the Secretary of the Treasury, and the others who deal as loosely with your money as they do with facts.

"The have-not nations have not machines. The world clamors for the products of American engineering. It rejects the competitive economy that creates them. In all world economies where competition is rejected the standard of living falls.

"When competitive enterprise functions in Europe, only the governments will suffer because their controls are reduced. The people will prosper because incentives will be restored. Fields will be tilled for the harvests and will belong to the people who till them. Workmen will work for a wage in honest money and will buy food and clothing. Families will return to their churches. Children will return to their schools. Wealth will return to their economies."

REPRESENTATIVES FROM MILWAUKEE, SCENE OF A.S.M.E. 1948 SEMI-ANNUAL MEETING

(*Left to right:* Mr. and Mrs. T. Eserkaln, Mr. and Mrs. LaRue Stark, and Mr. and Mrs. T. Wetzel.)

The evening, however, was not devoted entirely to speech making and the conferring of awards. A concert was also given by 48 artists. The "Alice Stephens Singers" made up of 40 young ladies and an octette of men presented choral music in the modern manner. Leo Terry, one of Chicago's leading organists, provided the background music during the banquet along with some specialty numbers. Don Fernando and his orchestra played for the dancing which followed in the Grand Ballroom.

Distinguished Guests at Banquet

Present at the banquet was W. L. Abbott, honorary member A.S.M.E., and president of the Society in 1926, whose introduction to the guests was greeted with tremendous applause. Prof. Rodolfo Emiliano Ballester, Calvin W. Rice Lecturer in 1939, of the University of Buenos Aires, was also present and spoke briefly during the banquet.

In attendance throughout the meeting was Col. L. F. Grant, president, The Engineering Institute of Canada, who was warm in his praise of the hospitality extended to him by the Chicago Section.

Fuels Luncheon

Coal reserves in this country are so enormous

that they can supply all U. S. requirements for the next 1500 years, Dr. Harold J. Rose, member A.S.M.E., vice-president and director of research, Bituminous Coal Research, Inc., Pittsburgh, Pa., told members and guests who attended the fuels luncheon on Wednesday. This applies to requirements for heat, light, power, transportation, and the smelting of metals; all liquid and gaseous fuels; and most synthetic chemicals, at the present rate of consumption with allowance for conversion efficiencies.

In contrast to the large coal reserves, the proved U. S. reserves of petroleum and natural gas would last only $8^1/_2$ years if they could be produced and used fast enough to supply their present markets, and to take over all present coal uses at the same Btu efficiency.

He pointed out that these facts are causing a great increase in the support being given to coal research by the coal industry itself, by federal and state governments, by the petroleum, gas, and chemical industries, and by equipment manufacturers. Expenditures on research and engineering development work closely related to coal are $15,000,000 or more annually, in this country, with large additional expenditures in England and other countries.

Dr. Rose then summarized some of the trends of solid-fuel research to meet the increasing demands that will be made on coal. He covered coal-mine mechanization, underground gasification, coal-preparation methods, transportation of coal, the use of coal for power, liquid fuels, and house heating.

Julian E. Tobey, member A.S.M.E., managing director, Fairmount Coal Bureau, New York, N. Y., presided.

Semi-Annual Business Meeting

The 1947 Semi-Annual Business Meeting of the A.S.M.E. was held on Monday afternoon. President O'Brien presided. The Nominating Committee for 1948 was elected. (See page 705 of this issue.)

For the Committee on Constitution and By-Laws, A. M. Gompf, chairman, presented a proposal to amend certain sections of the Constitution and By-Laws which relate to the Fellow grade of membership. The subject has been under study and discussion for many months by a special Fellow Grade Committee, consisting of J. N. Landis, A. C. Chick, and A. R. Mumford, which reported to the Council at the 1946 Annual Meeting. As a result of this study the Committee on Constitution and By-Laws submitted proposed amendments at the Regional Meetings and at the Regional Delegates Conference. Certain basic principles were agreed upon which resulted in the amendments proposed. Considerable discussion of the proposed amendments followed, and J. N. Landis gave a careful review of the history of discussions relating to the Fellow grade. It was voted to refer the proposed amendments to the members for letter ballot sometime in September.

Technical Program

The technical program at the 1947 Semi-Annual Meeting consisted of 32 sessions on a variety of subjects including heat transfer, metal cutting, management, power, aviation, fuels, process industries, metals engineering, furnace-performance factors, Diesel locomotive design, industrial instruments, education, materials handling, machine design, oil and gas power, rocket propulsion, and rubber and plastics.

AT THE NUCLEAR ENERGY SESSION
(*Left to right:* Alfred Nier, Al Baker, and B. R. Prentice.)

Heat Transfer

At the opening session under the auspices of the Heat Transfer Division, the first paper reported an investigation which dealt with the study of heat transfer by natural convection from vertical cylindrical surfaces to water and ethylene glycol, in both laminar and turbulent ranges. In another paper it was shown that the film coefficient of heat transfer from a hot metal surface to a boiling liquid may be estimated from experiments using an electrically heated wire submerged in the liquid. Different heated metals gave different boiling curves, it was pointed out, and at different elevated pressures the same heated metal gave different curves. The data presented related to nickel and chromium at 0, 25, 50, 75, and 100 psi.

A paper at the second session was devoted to the linear decrease of electric resistance with increasing temperature which occurs in electrolytes, melted and solid salts, semiconductors, and in all sorts of carbon. In another paper the authors had compiled experimental data dealing with viscosity of water and water vapor which had been obtained by various investigators.

Atomic Power Plants

Nuclear energy, gas-turbine, and power-engineering papers were featured at the eight Power Division technical sessions, some of which were held jointly with the Fuels, Heat Transfer, and Oil and Gas Power Divisions.

At a session devoted to atomic-power engineering on "Some Nuclear Problems" and "Some Design Problems," engineers were told that the use of atomic energy for practical power production depends upon the solution of many engineering problems which must be solved by the engineer and the nuclear physicist, working together.

It was pointed out that the construction of atomic reactors requires materials whose properties are largely unknown under the operating conditions. New materials will have to be developed so that the greatest efficiency of operation will be achieved. In all of this work the engineer will have to take account of the nuclear properties of material as well as properties already known.

Among the problems is that of the heavy shield that must be provided against the death-dealing emanations from the atomic-power plant.

While this rules out small mobile installations, such a weight of shielding would not be particularly detrimental in stationary units or in large propulsion units, such as might be used on ships.

A second problem has to do with the removal of waste products from any practical atomic "furnace." When an atomic fuel undergoes fission, elements near the middle of the atomic table are formed. For each atom of U-235 which is destroyed, two new lighter atoms are created. Some of these will have a low "cross section" for absorption of neutrons. Others will have larger values and will act as parasites in removing neutrons from the pile. In the Hanford plant, the problem was solved by removing the canned uranium slugs at regular intervals, dissolving the contents by a laborious chemical process, and separating out the uranium and plutonium for further work.

It was predicted that atomic power, sold as electricity, will in decades to come, form the basic large dollar-volume industry through which (1) low-cost atomic power benefits the nation's economy, (2) our resources of natural atomic fuel U-235 area ugmented by artificial fuel, and (3) radioactive isotopes are produced.

A brief sketch of some design problems in one possible atomic-power system, an explanation of a controlled nuclear chain reaction to help introduce the problems of the nuclear reactor, a detailed examination of some problems in the reactor, and some comments about the growth of atomic power were presented.

Industrial Power Plants

The economics of industrial steam plants were discussed from the viewpoint of the executive whose principal responsibility is the success of an enterprise; the plant operator or supervisor whose principal responsibility is to provide adequate and economical service; and the designer whose principal responsibility is to provide designs which will result in low investments, low operating costs, and adequate service. Each of these three groups has a vital function in the solution of economic problems. Examples were shown pointing out how their viewpoints can be reconciled and how economic technology is applied.

A few examples of economies in the design of public-utility power plants along the lines of first cost and availability were outlined.

Left to right: HAROLD J. ROSE; JULIAN E. TOBEY; E. W. O'BRIEN, PRESIDENT A.S.M.E.

A study of sulphate deposits on the tubes of an underfeed-stoker-fired boiler was presented. Data on the formation and analyses of deposits, the variation of acidity and sulphur content of fly ash from the boiler, and also of fly ash from various types of fuel-burning equipment, were presented.

A review of some heat-pump installations in the United States was presented. This paper appears in full on pages 639–647 of this issue.

A new method of "quick-starting" high-pressure steam-turbine units at locations where, on account of their light night loads, in comparison with heavy day loads, some of the high-pressure units must be shut down and started each night, was described. The new method reduces the thermal "start-up" stresses in the turbines and boilers, reduces the starting-fuel losses, reduces the personnel required, and increases the available reserve factor as compared with the conventional start-up methods.

Furnace Performance Factors

An investigation of the variation in heat absorption in a pulverized-coal-fired water-cooled steam-boiler furnace was presented in four parts: (1) Variations in heat absorption as shown by measurement of the surface temperature of the exposed side of furnace tubes. (2) Furnace heat-absorption efficiency as shown by the temperature, composition, and flow of gases leaving the furnace. (3) Variations in heat absorption as shown by density and velocity measurements of the fluid within a tube. (4) Comparison and correlation of the results of furnace heat-absorption investigations.

Boiler-Feedwater Studies

An investigation of boiler-drum steel after forty years of service was presented. Examination of materials from seven riveted boiler drums removed from service after 40 years' operation at a temperature and pressure of 3888 F and 200 psi has revealed no evidence of deterioration in the properties of the steel from which they were made.

The effect of inhibited hydrochloric-acid solutions on boiler tubes of various specifications was also discussed. Tests were made at 140, 160, and 180 F using three inhibitors and four concentrations of hydrochloric-acid solutions. The effect of acid concentration, temperature, and addition of boiler scale on the corrosion rates was shown.

Gas Turbines

The design features of a 4800-hp gas-turbine plant for locomotive and other applications was presented. It consists of a straight-through, in-line arrangement of compressor, combustion chambers, and turbine resulting in a maximum of simplicity and a minimum of pressure losses. This simple design was decided upon both on the basis of the study of the economics of the railway application and because simplicity is inherently desirable.

The plant is rated 4800 shaft horsepower for the locomotive application when running 6700 rpm with 1400 F turbine-inlet temperature. The design altitude is 1500 ft with 80 F ambient-air temperature.

The over-all thermal efficiency at the turbine shaft is expected to be somewhat over 17 per cent, after allowance for all losses and for power for power-plant auxiliaries. This efficiency is based on the lower heating value of the Bunker C fuel.

Left to right: JOHN I. YELLOTT, JOHN T. RETTALIATA, AND CHARLES F. KOTTCAMP

The 15-stage axial-flow compressor pumps approximately 70,000 cfm through a pressure ratio of about 6 to 1.

There are six all-metal combustion chambers, in which the Bunker C fuel is burned.

The power plant forms an integral unit and no base is required for it.

As installed it will drive direct-current generators through a reduction gear. Such generators and gearing are being used for the power-plant tests. The base of girder construction resembles part of a main frame of a locomotive.

Besides the locomotive application, it is expected this unit will prove attractive for other applications such as for industrial power, automatic peak-load plants for power systems, oil-field, or pipe-line applications. It is expected that almost any liquid or gaseous fuel can be used. For some applications steam might be produced from the exhaust gases.

Preliminary studies indicate this same unit can be adapted readily to a pulverized-coal-burning plant if and when the combustion and ash problems have been overcome.

An economic evaluation of the prospects of the coal-burning gas turbine, particularly as applied to the locomotive, was given. The program of the Locomotive Development Committee was outlined and attention was given to the probable applications of this type of power generator.

The coal-burning system under development by the Committee was analyzed and the solutions being studied were discussed in some detail. The coal, crushed to a fine size, is subsequently handled entirely by air. Drying of the coal, necessary to enable it to be fed in a fluidlike manner, is accomplished through the use of waste heat from the gas turbine. Pressurizing is accomplished by the use of several forms of "coal pump."

Recent developments in the "coal atomizer" were given with test data on a wide variety of coals.

The fly-ash problem was discussed in some detail. The ability to remove the coarser fragments of the fly ash apparently eliminates the danger of abrasion of the turbine blades; but, under turbine conditions of high temperature and relatively high velocity, a deposit is formed by the finer particles. It has been found that this deposit can be removed readily by proper washing.

The estimated performance of coal-burning gas-turbine power plants in which all of the auxiliaries are taken into consideration was presented. The possibilities of using waste-heat boilers were also mentioned.

The preliminary development and testing of a combustor for a 2200-hp gas turbine was discussed. The test equipment and instrumentation required to evaluate gas-turbine combustor performance was described. Test operating conditions which would duplicate actual operation in the turbine unit were presented. The performance of a combustor designed to operate on residual fuel oil was considered. Some problems encountered in devising satisfactory ignition equipment and securing fuel atomization over a wide range of combustion rates were reviewed.

A paper discussing the modern gas turbine in the industrial power plant was presented and appears in full on pages 475–478 of the June, 1947, issue of MECHANICAL ENGINEERING.

Art of Metal Cutting

Three papers dealing with metal cutting were presented by the Production Engineering Group. Recent developments in the art of metal cutting have promoted extensive research into the various factors which influence the reactions between the tool and the workpiece and this research was reflected by these papers.

Torsional stresses set up in twist drills, chip contours, and their relationship to the mechanics of metal cutting, and the temperatures developed in the chip and surface of contact as covered at this session all indicated that further research and study is necessary before the greatest efficiency of present methods and cutting tools can be obtained.

The interest shown in these papers indicates that industry recognizes the need for further information of a factual nature on the subjects covered.

The two sessions held under the auspices of the Metals Engineering Group were divided between the study of castings, with the emphasis on steel, the extrusion method of manufacturing the various alloys, and the application of welding methods in the saving of machine time.

Alloy cast steels are finding new applications in engineering problems and the advisability of a further study of the properties of steel cast-

OVERFLOW CROWD AT ONE OF THE POWER SESSIONS

ings and their application to new design is definitely indicated. Recent research has determined these properties within reasonable limits and the results can well be used in an analysis of future needs.

The advantages of centrifugal castings were very well presented and the indications are that there will be a growing application of this method of casting where hollow sections are needed, eliminating the necessity of forging such shapes, or of drilling a solid block after forming.

The advantages of pressure welding were demonstrated in the construction of the aircraft-propeller hub. Through the application of this method it had become possible to eliminate much of the time required for machining the hubs from the solid piece. The method described opens the way for the redesign of parts with a material saving in costs as well as a greatly increased production.

The sessions sponsored by the Machine Design Group covered a wide variety of subjects and so were applicable to a number of different fields in engineering.

Properly designed couplings using gears to replace the Hooke's joint promise a more uniform transmission of power. Deviation from fundamentals in the design of internal shoe clutches leads to poor design and future trouble.

The use of brittle coatings in the study of stress distribution may present the solution to many problems now faced in design. This method can be used effectively in the study of residual and locked up stresses in parts such as crankshafts where the correct analysis of a part that has failed may have a material effect on future design. (See pages 567–571 of the July issue of MECHANICAL ENGINEERING.)

Beryllium copper now offers a high-performance material that finds its application in a number of parts formerly made of other materials. The ease with which this metal can be formed, together with its long service life and resistance to corrosion, make it ideal for many applications, according to the author of the paper on this subject. This paper is published in full on pages 651–654 of this issue.

A theory on critical speeds as applied to small overhung abrasive wheels was developed through the study of a large number of curves. These curves were based on a long series of tests run to determine the relationship between the factors producing vibration and whipping. A study of the curves shown and the theory developed may give the answer to problems as yet unsolved.

Process Industries

Two papers presented at the first session of the Process Industries Division dealt with the subject of waste. One paper on industrial-waste disposal outlined general aspects of stream pollution and sewage treatment as background for an understanding of the handling of industrial wastes. Typical wastes were described by population equivalent or other characteristics, their deleterious characteristics were pointed out, and the manner in which treatment may be effected in typical cases was reviewed.

The second paper, which was directed to the elimination of waste products of high moisture content in a gas-turbine system, reviewed a number of high-moisture fuels and commented on methods of burning them. A gas-turbine system, devised primarily for the combustion of fuels normally considered to be of low value because of their high moisture content, was described, and a field for the application of the system was suggested.

At the second session, a paper dealing with vertical pressure leaf filters described design features as related to many product applications and was accompanied by slides showing the sequence of operations for several types of pressure systems of various filter-aid feeding devices and fluid controls. Limitations of viscosity, particle size, total solids, and economies were given in detail. Field case histories were summarized.

In a paper on distilling-plant economy an attempt was made to analyze the performance of various plants in terms which would permit comparisons.

Diesel Locomotive Design

Under the auspices of the Railroad Division a forum on Diesel locomotive design for reduced maintenance was conducted. Participating in the forum were consulting engineers and representatives of the manufacturers of Diesel locomotives.

Industrial Instruments

In the field of industrial instruments a session was held under the auspices of the Industrial Instruments and Regulators Division and the A.S.M.E. Research Committee on Elevators. The first paper dealt with the centrifugal governor in elevator service. The second paper described a speed detector using a hydraulically driven gyroscope as a sensitive element.

Co-Operative Education

Two points of view on the co-operative-education plan were presented at a session under the auspices of the Education Committee. The first considered the point of view of the educational institution. It reviewed the present objectives, the administrative and operating requirements, the benefits to both student and industry, and the potential contribution of the plan to the achievement of the broader concepts of engineering education. The second paper described the co-operative plan as it is carried out in the Buick Motor Division of the General Motors Corporation, where both shopwork and classroom work are conducted by the Corporation.

T. S. MC EWAN (*left*), D. ROBERT YARNALL (*center*) AND H. CROFT (*right*) ENJOY CHAT AFTER GENERAL LUNCHEON ON MONDAY

POWER SESSION

Materials Handling

Persons attending the Materials Handling sessions had an opportunity to see a motion picture, "From Trees to *Tribune*," which illustrated the use of materials-handling equipment in the pulp and paper industry. The picture was followed by a discussion of the place of material in postwar production.

At the second materials-handling session machinery involved in a typical solvent-extraction plant for the recovery of vegetable oil was described. The selection of proper conveyers at various points in the process was discussed and the reasons for selection were commented on.

The third materials-handling session was held jointly with The Engineering Institute of Canada and was devoted to coal and ash handling. A paper describing coal handling with earth-moving equipment, which was published in MECHANICAL ENGINEERING for July, was followed by one on coal and ash handling at the modern boilerhouse.

Rubber and Plastics

Under the auspices of the Rubber and Plastics Division three papers were presented. The first described the Buick motor-mount testing machine designed and built for the purpose of providing an adequate and convenient means of determining the rate, hysteresis, and life expectancy of motor mounts. The second discussed factors which may affect the performance of aircraft hydraulic packings. Some properties and mechanical applications of compars were discussed in a third paper.

Management Sessions

The four sessions under the auspices of the Management Division had been carefully planned and were expertly handled. The papers discussed such subjects as human behavior in employee-employer relations, incentives, profit sharing, junior executives' place in production, labor relations, dealing with the union, and today's pattern of industrial relations. All sessions were well attended, all the speakers gave excellent presentations, and all subjects were exhaustively discussed by means of questions written by members of the audience and answered by the authors. It is hoped that the papers will be

published in an early issue of MECHANICAL ENGINEERING for the benefit of readers who were not present at Chicago.

Aviation Subjects

Variety of subject matter characterized the three sessions of the Aviation Division. At the first session interest was centered in passenger comfort and the papers were devoted to silencing aircraft, and passenger-service requirements for North Atlantic operations. A third subject, discussed at a later session, dealt with aircraft-cabin supercharging and air-conditioning by engine bleed-off.

At a session held jointly with the Oil and Gas Power Division and the American Rocket Society, pertinent features of liquid-propellant-rocket-power plants, general performance characteristics, and problems to be solved to improve reliability and performance were discussed in one paper, while another described the problems associated with research-aircraft design, particularly in reference to the XS-1 and its power plant.

The third session, held in co-operation with the Metals Engineering Division, afforded an opportunity for a discussion of precision-cast blades for aviation gas turbines, disk-forging developments in aircraft gas-turbine rotors, and the fatigue testing of gas-turbine alloys by means of a 120-cycle electromagnetic fatigue machine.

Calumet Station

The Calumet Station of the Commonwealth Edison Company, one of four electric generating stations located in Chicago, was visited on Tuesday afternoon. Many developments were proved here for application in plants burning midwestern coal. Car-dumper use in generating stations, steel-tube economizers, 20-ft-wide chain-grate stokers, overfire-air injection, air preheaters used with stokers, bin and unit system pulverized-coal firing, combination gas and coal firing, horizontal and vertical cyclone-burner development, feedwater deaeration and treatment, closed regenerative-feedwater systems, and horizontal isolated-phase switch-house design, all were developed here or were proved for use in Commonwealth Edison system stations. At Calumet Station the visitors saw evidence of these developments and the latest capacity addition to the Edison system in the form of a 107,000-kw unit, the steam generators of which were in operation.

Armour Research Foundation

The Armour Research Foundation of Illinois Institute of Technology, a nonprofit industrial-research laboratory which was founded in 1936, was also visited on Tuesday. The foundation occupies three buildings on the Institute campus on Chicago's South Side. The total number of employees is 445 of which 287 comprise the technical staff. Research is carried on in eight major fields: Ceramics and minerals, mechanics of solids, physics, metals, electrical engineering, chemistry and chemical engineering, mechanical engineering, and fluid mechanics and thermodynamics. In addition to research projects for industrial sponsors, the Foundation engages in considerable fundamental research under an endowment system. The equipment

MR. AND MRS. GEORGE M. BICKFORD AND MR. AND MRS. S. GRANVILLE SMITH

and facilities available for carrying out research projects were shown to the visitors.

International Harvester Company

The Melrose Park Works, the newest of the three plants in the International Industrial Power Division network, was inspected on Wednesday. Acquired in 1945, the plant, which was built just before Pearl Harbor for the production of bomber engines by the Buick Motor Car Company, has more than 2,000,000 sq ft of floor space and is laid out for streamlined production of industrial engines and tractors. The visitors saw the castings, received from International's Milwaukee Works, being machined and assembled into complete engines at the Melrose Park Works. The new TD-24 Diesel Crawler, largest and most powerful crawler tractor ever built, is also a product of this plant.

Western Electric Company

Also on Wednesday a group visited the Western Electric Company's gigantic Hawthorne Works in Chicago. The visitors saw the processes of manufacturing telephones.

The plant now is producing telephones at the rate of 12,100 every day, having made nearly 2,500,000 in 1946 and setting its sights on a goal of more than 3,500,000 this year.

The plant which is windowless, has a net floor space of 792,449 sq ft. Overhead conveyers, the operation of punch presses, and plastic molding, are a few of the things that the visitors inspected.

Inspection Trips

A schedule of six interesting inspection trips for Monday, Tuesday, and Wednesday afternoons was arranged. Each day a choice of two visits was available, illustrating different aspects of Chicago's industrial panorama.

The Corwith Works of Crane Company, said to be the world's largest plant devoted to the manufacture of valves, fittings, and fabricated piping, was visited on Monday. Facilities for casting valves and fittings in sizes from $\frac{1}{8}$ in. to 72 in. of some 15 kinds of steel, 11 brass compositions, cast and malleable iron, and many special alloys were inspected. Up to 250 tons of steel and more than 110 tons of brass are poured every day. The visitors saw the pipe-fabricating shop which is equipped to produce special bends and welded assemblies for all piping requirements in sizes up to 30 in. O.D. Some of the special inspection and testing techniques in use throughout the plant to insure quality control of the more than 30,000 items manufactured were viewed.

Onsrud Machine Works

The visit to the Onsrud Machine Works was of major interest to members of the Wood Industries Division since this company is a leader in the development and production of woodworking machinery. The metal industries were also interested, however, since the Onsrud Spar Mill and Onsrud Router Bits have played a leading part in the production of aircraft.

Onsrud machines are used quite generally both in Government arsenals and private industries for producing gun stocks both in the U. S. and Europe. An interesting collection of these stocks was on display.

In addition to the large stationary machines a series of portable grinders has been developed that incorporate unique features making for light weight, low power, and high speed. These features include turbine drive, centrifugal force, lubrication, and speeds as high as 75,000 rpm operating on air pressures of from 90 psi to 100 psi. The power developed ranges from $\frac{1}{16}$ hp to $2\frac{1}{2}$ hp.

A self-lubricating milling cutter has recently been developed using two carbide-tipped wings. Lubrication of the cutting edges is obtained by a combination of vacuum and centrifugal force through porous plugs set in the cutter body. A 60-hp motor driving this cutter at from 7500 rpm to 22,000 rpm and at feeds from 100 ipm to 20 fpm through 24S-T aluminum alloy has produced blocks having a finish of less than 5 microinches and so perfectly machined that they adhere to each other.

Women's Program

The Women's Committee of the A.S.M.E. Chicago Section, under the chairmanship of Mrs. A. B. Openshaw, arranged an entertaining program for the visiting members and guests of the A.S.M.E. Woman's Auxiliary.

On Monday, June 16, a trip was made to the Adler Planetarium where a lecture was given. On the following day an interesting bus trip covered part of the South Side of the city, through Lincoln Park as far north as the Edgewater Beach Hotel, where luncheon was served in the beautiful Marine Dining Room. The visitors were entertained by Madam Zola

RICHARD TEDROW (*left*), TING HWA CHIEN (*center*), AND JAMES CHI MA (*right*)

and Madam Marsha, and after luncheon returned to the Stevens Hotel. On Wednesday, June 18, Marshall Field's department store was visited, where luncheon was served in the store's Walnut Room, and a fashion show viewed. After luncheon a conducted tour of the store was enjoyed. Three beautiful Marshall Field hats were given away to members of the party as door prizes by the committee.

Committees

Members of the committees of the A.S.M.E. Chicago Section who worked hard to plan and organize the 1947 Semi-Annual Meeting, were:

General Committee: J. R. Michel, chairman, R. H. Bacon, vice-chairman, H. W. Cross, secretary, F. A. Faville, assistant secretary, T. S. McEwan, vice-president, Region VI.

Reception: W. T. McCullough, Jr., chairman, L. M. Johnson, vice-chairman, C. S. Becker, L. A. Ferguson, C. O. Hoban, A. L. Mitchell, G. D. Olson, and P. F. W. Waller.

Registration: V. G. Leach, chairman, R. B. Gutekunst, R. J. Hinch, J. C. Marshall, and I. L. Wade.

Hotel: S. E. Winston, chairman, R. V. Dondanville, G. C. Laughlin, C. W. Parsons, and W. H. Pletta.

Technical Sessions: O. F. Campbell, chairman, W. H. Oldacre, vice-chairman, H. E. Deady, W. E. East, H. S. Nachman, J. D. Pierce, D. G. Reid, and C. H. Simmons.

Finance: P. F. W. Waller, chairman, and F. H. Lane.

Publicity: C. C. Austin, chairman, J. B. Burkhart, A. H. Jens, J. D. Pierce, and R. E. Turner.

Printing and Signs: F. H. Lane, chairman, W. C. Kramer, D. I. Payne, and D. G. Reid.

Entertainment: A. B. Openshaw, chairman, Ralph Sargent, vice-chairman, R. K. Behr, C. J. Clark, W. A. Dundas, and S. B. Smith.

Inspection Trips: J. P. Magos, chairman, R. D. Brizzolara, vice-chairman, W. A. Dundas, J. W. Kendrick, J. F. Sullivan, and E. H. Taylor.

Student Group: B. H. Jennings, chairman, J. F. Bailey, and R. A. Budenholzer.

Women's Committees

Reception: Mrs. A. D. Bailey, Mrs. F. H. Lane, and Mrs. A. B. Openshaw.

Registration: Mrs. E. C. Bailey and Mrs. H. C. Boardman.

Entertainment: Mrs. R. H. Bacon, Mrs. Alexander Cowie, Mrs. W. A. Dundas, Mrs. R. J. Hinch, Mrs. B. H. Jennings, Mrs. J. C. Marshall, Mrs. T. S. McEwan, Mrs. J. R. Michel, Mrs. G. D. Olson, Mrs. C. W. Parsons, and Mrs. J. F. Sullivan.

New Labor Law Guarantees Rights of Professional Employees

WITH the enactment into law of the Taft-Hartley labor bill, engineering employees can no longer be forced by labor unions to participate in collective-bargaining units not of their own choice. The new law, The Labor-Relations Act, 1947, recognizes that professional employees have problems distinct from those of laborers and skilled workmen and guarantees to professional employees the right to decide for themselves, by majority vote of those affected, whether they want to refrain entirely from any collective-bargaining procedure, whether they wish to have a collective-bargaining unit composed exclusively of professional employees, or whether, in any particular instance, they prefer to be included with other types of employees in a heterogeneous bargaining unit.

Sections of the Act of particular interest to professional employees are as follows:

"Sec. 2 (12) The term 'professional employee' means—

"(*a*) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual or physical processes; or

"(*b*) any employee, who (i) has completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (*a*), and (ii) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (*a*)."

"Sec. 9 (*b*) The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by the Act, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof; Provided, That the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unit."

According to E. L. Chandler, chairman of the Engineering Societies Labor Legislation Panel, the engineering profession is particularly indebted to Senator Joseph H. Ball and Congressman Carl Hinshaw for sponsoring bills which recognized the need for special treatment of professional employees under the labor laws. The definition of "professional employees" contained in the compromise Taft-Hartley bill was taken from Senator Ball's bill, S. 360.

In order to place the views of engineers before the Congress, the Engineers Joint Council sponsored an Engineering Societies Labor Legislation Panel composed of one member of the following societies: American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Society for Engineering Education, and the National Society for Professional Engineers. Presentations made by the Panel before Congressional Committees were supported by the American Institute of Architects and the American Chemical Society.

William F. Ryan, Fellow A.S.M.E., assistant engineering manager, Stone & Webster Engineering Corporation, Boston, Mass., represented the A.S.M.E. on the Panel.

New Records to Facilitate A.S.M.E. Appointments

DURING the last 10 years more than 6500 engineers served on the 959 boards, committees, and other administrative units which conduct the business and determine the policies of the A.S.M.E. This fact was revealed by a study of the record of committee service recently compiled for every member of the Society.

Because the quality of Society activities is determined to a large degree by the ability and qualifications of the personnel appointed to boards and committees, two new administrative tools have been devised at headquarters which should permit maximum dispersal of administrative and research responsibilities among qualified members of the Society. The first of these is a record of committee service for each member which provides information on past and present service. The other is a file of members possessing special experience or qualification to recommend them as potential candidates for committee service.

To maintain these records up to date, headquarters has revised the biographical- and professional-data questionnaire. This will be sent to one fifth of the Society membership each year. Once every five years each member will automatically have the opportunity to add biographical data to his professional record maintained by the A.S.M.E. and to express preference for committee service. Otherwise, members who wish to serve on Society committees may notify headquarters at any time so that their names may be included in the file of potential candidates.

Fellowships Available

THE Institute of Gas Technology, Chicago, Ill., is offering four fellowships to qualified men under twenty-eight years of age who have their bachelor's degree in mechanical engineering. Successful completion of the required program of studies leads to the degrees of master and doctor in gas technology. These degrees are granted by the Illinois Institute of Technology with which the Institute of Gas Technology is affiliated. Fellowship remuneration for the coming year is $125 per month for ten months and ex-service men are, in addition, entitled to the usual Veterans Administration educational allotment. Tuition and fees are free and all remuneration is tax-free.

For details, address The Director, Institute of Gas Technology, 3300 Federal Street, Chicago 16, Illinois.

Actions of the A.S.M.E. Council

At Meetings Held at Chicago, June 15 and 16

THE Council of The American Society of Mechanical Engineers met in two sessions during the 1947 Semi-Annual Meeting at the Stevens Hotel, Chicago, Ill., June 15 and 16, 1947.

Present at one or both of these sessions were: Eugene W. O'Brien, president; Alex D. Bailey, R. M. Gates J. W. Parker, D. Robert Yarnall, past-presidents; S. R. Beitler, J. Calvin Brown, A. C. Chick. N. E. Funk, Linn Helander, T. S. McEwan, A. R. Mumford, E. E. Williams, vice-presidents; W. A. Carter, E. J. Kates, A. J. Kerr, J. N. Landis, directors at large; R. L. Goetzenberger (Education and Professional Status); A. M. Gompf H H Snelling (Constitution and By-Laws); M. R. Bowerman, L. J. C. Cucullu, R. C Dannettel, J. B. Jones, R. G. Roshong (Nominating); L. N. Rowley, Jr. (Publications); R. Michel, J. C. Marshall, A. C. Pasini (Regional Delegates); J. B. Burkhardt (Junior observer); J. M. Robert, S. D. Moxley, Arthur Roberts, Jr., T. L. Wilkinson (Guests); C. E. Davies, secretary; George A. Stetson, editor; D. C.A. Bosworth, comptroller; and Richard Tedrow, staff.

1947–1948 Budget

Following a review, a statement of policies, an estimate of income, and a budget of expenditures for 1947-1948 were approved. These are published on pages 699 and 700 of this issue.

Amendments to By-Laws

The first reading of the proposed amendment to article B9, Paragraph 5, was accepted. This amendment changes the title of the Committee on Meetings and Program to Meetings Committee.

Amendment to Rules

Upon recommendation of the Constitution and By-Laws Committee it was voted to amend the following Rules: R9, Rule 1, Meetings of the Society; R10, Rule 7, Professional Divisions and Groups; and R15, Rule 1, 2, and 3, Professional Practice. The changes in R9 and R15 are intended to make the committee names conform to those used in the new Society organization. The amendment to R10 concerns appointment of Professional Division secretaries without prior approval by the secretary of the Society.

1948 National Meetings

The following National Meetings to be held in 1948 were approved; Spring Meeting in New Orleans, La., March 1 to 6; Semi-Annual Meeting in Milwaukee, Wis., May 30 to June 5; Annual Meeting in New York, N. Y., Nov. 28 to Dec. 4. (The Fall meeting to be held in Portland, Ore., had been approved at a previous meeting of the Council.)

New Publication Plan

Upon recommendation of the Board on Technology, it was voted to approve the new publication plan designed to improve service to members and to cut costs of publications, but to refer the plan back to the Board on Technology and the Finance and Executive Committees and later to submit the entire plan to membership for letter-ballot action as provided for in the By-Laws.

Fees at National Meetings

It was voted to accept the recommendation of the Board on Technology that a fee of five dollars be charged to non-members for admission to one or all general or technical sessions at the four A.S.M.E. national meetings.

Regional Delegates Conference

Following an oral report by Carl J. Eckhardt, Jr., speaker, 1947 Regional Delegates Conference, on the discussion and recommendations of the Conference, it was voted to refer the recommendations to the A.S.M.E. Committees concerned and to await their reports before taking further action.

The Secretary was directed to send to all regional delegates an expression of appreciation on behalf of members for services rendered to the Society.

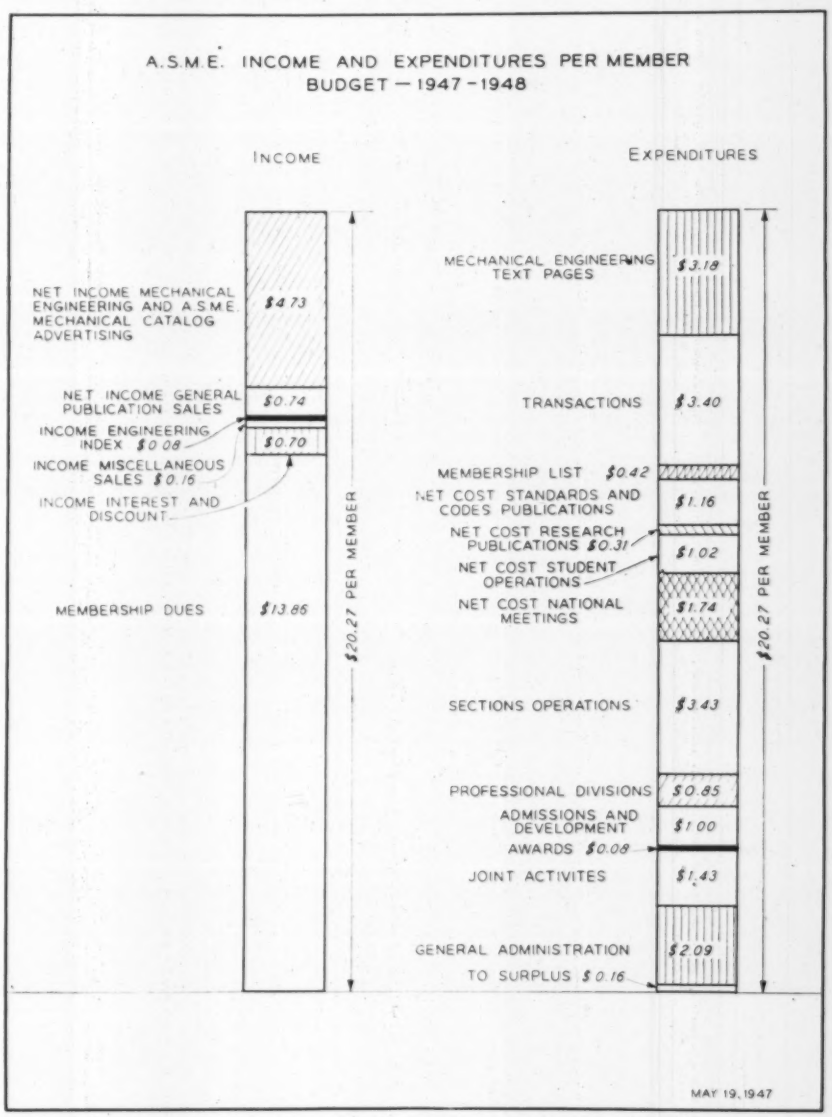


CHART SHOWING NET A.S.M.E. INCOME AND EXPENDITURES PER MEMBER BASED ON BUDGET FOR 1947-1948

(*Left:* Sources of net A.S.M.E. income. *Right:* How net income is expended to support, wholly or in part, A.S.M.E. activities that are not fully self-supporting. The chart is based on the net amounts listed in the second column of the table on page 698, "Breakdown of A.S.M.E. Budget, 1947-1948." The chart values, dollars per member, were derived by dividing the amounts in the table by the anticipated number of members, 23,800. Amounts in the table include indirect costs; and it must be recognized that allocation of many items of indirect costs is a matter of judgment.)

BREAKDOWN OF A.S.M.E. BUDGET—1947–1948

		Budget 1947–1948
MECHANICAL ENGINEERING and Mechanical Catalog income	$345,000.00	
Less production costs, wages and indirect	232,296.00	$112,704.00
General publication sales income	$ 45,000.00	
Less stock cost, wages and indirect	27,394.00	17,606.00
Engineering Index		2,000.00
Miscellaneous sales		4,000.00
Interest and discount		17,000.00
Membership dues		330,000.00
TOTAL		$483,310.00
MECHANICAL ENGINEERING text (production, wages and indirect)		$ 75,880.00
Transactions (production, wages and indirect)		80,942.00
Membership List (production, wages and indirect)		10,020.00
Standards and codes (income)	$ 70,000.00	
Stock cost, wages, sales and indirect	97,755.00	27,755.00
Research (income)	$ 8,000.00	
Research (wages, sales and indirect)	15,446.00	7,446.00
Student dues	$ 30,000.00	
Student expense (production, wages and indirect)	54,432.00	24,432.00
Meetings income	$ 8,000.00	
Meetings expense (costs, wages and indirect)	49,516.00	41,516.00
Sections (appropriations, travel, wages and indirect)		81,752.00
Divisions (appropriations, wages and indirect)		20,355.00
Admissions and development (wages and indirect)		23,879.00
Awards (costs, wages and indirect)		1,897.00
Joint activities		34,044.00
General administration		49,702.00
TOTAL		$479,620.00
NET INCOME		$ 3,690.00

National Security Act of 1947

Upon recommendation of the Board on Public Affairs, it was voted to endorse the National Security Act of 1947 (Gurney Bill S. 758). This is a bill "to promote the national security by providing for a National Defense Establishment, which shall be administered by a Secretary of Defense, and for a Department of the Army, a Department of the Navy, and a Department of the Air Force within the National Defense Establishment, and for the coordination of the activities of the National Defense Establishment with other departments and agencies of the Government concerned with national security."

National Legislation

Following a discussion on how the Society could express its point of view on national legislation, it was agreed that the following methods could be used: (1) By taking a poll of the membership; (2) by adopting a resolution at a business meeting; (3) by having the Council or the Board on Public Affairs express an opinion in its own behalf; and (4) by appointing a qualified individual to speak for the Society.

Whatever method is used, it was agreed that the statement of opinion should make clear what agency or division of the Society is endorsing it.

Honorary Members

Upon recommendation of the Board on Honors the following were elected as honorary members of the Society: Everett G. Ackart, Harvey N. Davis, Francis Hodgkinson, and Secretary of State George C. Marshall.

Policy on Income and Expenditure

The following statement of policy regarding income and expenditures and the budget for 1947–1948 were approved:

1 A continuous effort will be made to collect dues by regular monthly billings. Quarterly payments will be accepted.

2 No appropriation shall be made by Council without first referring back to the Finance Committee for recommendation. When a liability is assumed the means for paying for it shall be provided in advance.

3 No new activity shall be undertaken without definitely showing that the funds required to support it will be available without decreasing the appropriations for existing essential activities, giving the consideration to the administrative expense that may be involved. When a new activity is authorized if the additional funds to support it are not directly available from the unappropriated income, Council shall say what activity shall be curtailed or suppressed to permit transference of the fund required to support the new activity. If the budget of expenses is to be reduced, the Council shall say what activity shall be curtailed or suppressed.

4 The Society shall hold four general meetings with expense chargeable to the 1947–1948 budget. A fee of $5 shall be charged nonmembers for admission to general or technical sessions at the four National Meetings of the Society. The amount of the fee shall be the same for attendance at one or all of the sessions at a meeting. If a non-member is the author of a paper presented at a meeting he shall be exempt from payment of the registration fee for that meeting; there shall be no other exemptions.

5 Council meetings shall be held at Atlantic City in November-December, 1947, and at Milwaukee in May-June, 1948. Council representation within the budget shall be provided for the other national meetings.

6 Within the allowance of the budget, Vice-Presidents shall be expected to visit Sections and student branches and attend student branch conferences in their regions or arrange for visits by their representatives.

7 No travel allowance will be provided for Committee Chairmen attending Council meetings except upon special provision of Council or the Executive Committee.

8 Eight Regional Administrative Committee meetings will be held.

9 The Nominating Committee shall hold a preliminary meeting at a place to be selected and a selection meeting at the place of the Semi-Annual meeting.

10 The following uniform basis of contribution toward travel expense shall be adopted:

5 cents per mile one way plus allowance of $3.50 per diem for time at the meeting not exceeding two days plus total traveling time by standard railroad route plus 50 per cent for the Council, Nominating Committee, Regional Administrative Committees, Sections and Regional Delegates. When Board and Committee Chairmen are required to attend Council meetings, the same provisions will be made.

For Student Branch Conference—13 cents per mile one way for one delegate from each Student Branch.

Visits of President and Vice-Presidents or their designated representatives to Sections, Branches, etc.—out of pocket expense within budgetary limits prescribed.

11 The Society shall have two representatives on the American Standards Association.

12 No publications shall be printed for sale unless there is reasonable assurance of sufficient orders to pay for the cost.

Action of the A.S.M.E. Executive Committee

A MEETING of the Executive Committee of the Council was held in the Stevens Hotel, Chicago, Ill., June 15, 1947. There were present: Eugene W. O'Brien, chairman, A. C. Chick, J. N. Landis, A. R. Mumford, and C. E. Davies, secretary. Others present were: Alex D. Bailey, S. R. Beitler, J. Calvin Brown, R. M. Gates, Linn Helander, E. J. Kates, T. S. McEwan, and D. Robert Yarnall of the Council; H. H. Snelling (Constitution and By-Laws and Nominating Committees), and R. G. Roshong (Nominating Committee).

International Management Congress

It was voted to appoint as honorary vice-presidents A.S.M.E. members who were to form the A.S.M.E. delegation to the Eighth International Management Congress to be held

in Stockholm, Sweden, July 3 to 8, 1947. These were: W. L. Batt, Wallace Clark, C. E. Davies, A. E. Dodd, Alonzo Flack, Lillian M. Gilbreth, C. H. Hatch, A. B. Holmstrom, H. A. Hopf, Sidney Knight, J. P. Kottcamp, H. B. Maynard, L. C. Morrow, E. H. Schell, W. W. Tangeman, J. A. Willard.

Engineering Councils and Clubs

Following discussion of a report by the E.J.C. Committee on Organization of the Engineering Profession, which recommended that the national societies of E.J.C. encourage their Sections to work co-operatively with each other and with other engineering organizations not constituent bodies of the E.J.C., it was voted to distribute the E.J.C. report to A.S.M.E. Sections with the suggestion that in localities where there is no local co-operating organization, such an organization be formed.

Agreement of Co-Operation

The receipt from the Belgian Institute for Promotion of Applied Research in Industry and Agriculture of a signed agreement of co-operation was noted. This agreement was authorized by the Committee on Feb. 20, 1947. Under its provisions the Society will co-operate in arranging interchange of research workers and lecturers between the two countries.

Centenary Celebration

In response to an invitation from The Royal Netherlands Institution of Engineers for the Society to send an official delegation to its centenary celebration to be held in Holland during the week of Sept. 22, 1947, it was voted to accept the invitation and to appoint a delegation to attend the celebration.

Reciprocal Arrangement

It was voted to approve an arrangement suggested by The Institution of Engineers, Sydney, Australia, by which the secretaries of the two organizations would become members of the other without payment of dues.

San Diego Sub-Section

The formation of a sub-section of the Southern California Section in San Diego, Calif. to include the county of San Diego, was approved.

Certificates of Award

Upon recommendation of the Regional Delegates, Certificates of Award were approved for Carl J. Eckhardt, Jr., speaker of the 1947 Regional Delegates Conference and A. C. Pasini, chairman of the 1947 Agenda Committee.

B. A. Bakhmeteff Honored by France

ONE of the highest scientific awards of France, the Medal d'Officier d'Academie and de L'Instruction Publique, was conferred on Boris A. Bakhmeteff, member A.S.M.E., professor of hydraulics, Columbia University, New York, N. Y., for his contributions in the field of hydraulics.

The presentation was made on June 12, 1947, at the French Embassy, New York, N. Y., by Ludovic Chancel, Consul General of France.

BUDGET FOR THE YEAR 1947-1948

	Actual 1945-1946	Budget 1946-1947	Budget 1947-1948
INCOME			
Initiation and promotion fees to surplus	$ 24,135.00	$ 20,000.00	$ 25,000.00
Membership dues	301,260.23	315,000.00	330,000.00
Student dues	9,662.30	24,000.00	30,000.00
Interest and discount	14,606.30	16,500.00	17,000.00
MECHANICAL ENGINEERING advertising	289,645.80	265,000.00	255,000.00
Mechanical catalog advertising	101,084.50	100,000.00	90,000.00
Publication sales	109,518.69	119,000.90	123,000.00
Miscellaneous sales	4,384.76	4,000.00	4,000.00
Engineering Index, Inc.	1,825.00	2,282.00	2,000.00
Registration fees	585.00	776.00	8,000.00
TOTAL INCOME	$832,572.58	$846,558.00	$859,000.00
EXPENSES			
Expense under committee supervision	$140,624.28	$149,720.00	$154,277.00
Publication expense	238,867.03	256,300.00	260,800.00
Office expense	449,307.23	440,248.00	440,233.00
TOTAL EXPENSE	$828,798.54	$846,268.00	$855,310.00
NET INCOME TO DATE	$ 3,774.04	$ 290.00	$ 3,690.00

BUDGET FOR THE YEAR 1947-1948

	Actual 1945-1946	Budget 1946-1947	Budget 1947-1948
EXPENSE UNDER COMMITTEE SUPERVISION			
Council	$7,610.90	$6,000.00	$6,000.00
Regional Administrative Committee	6,620.83	6,200.00	6,200.00
Library	10,385.60	10,745.00	11,242.00
Regional vice-presidents		1,800.00	1,800.00
Section committee mileage	657.53		
Group delegates conference	1,519.40	1,500.00	1,500.00
Section operation	36,534.11	37,500.00	45,000.00
Awards	678.37	1,000.00	1,035.00
Nominating Committee	1,199.21	1,775.00	2,000.00
Relations with colleges mileage	793.95		
American Standards Association	1,000.00	1,000.00	1,000.00
Professional services	2,220.45	2,250.00	2,500.00
Divisions operation	4,691.98	4,975.00	5,000.00
Journal of Applied Mechanics	194.68	200.00	200.00
Society meetings	17,395.14	15,000.00	15,000.00
Student branch operation	8,538.89	12,000.00	15,000.00
Retirement Fund	22,680.78	23,700.00	23,800.00
E. C. P. D.	2,416.00	1,925.00	1,700.00
Membership development	2,500.00	6,000.00	
Organization charts	500.00	500.00	500.00
General committee expense	364.08	450.00	300.00
Engineers Registration Committee	350.00	500.00	500.00
Publicity expense	7,440.38	8,000.00	8,000.00
Employment reserve	2,000.00	2,000.00	2,000.00
Engineers Joint Council	2,332.00	2,200.00	1,500.00
U. E. T. Pension Fund		2,500.00	2,500.00
TOTAL	$140,624.28	$149,720.00	$154,277.00

BUDGET FOR THE YEAR 1947-1948

	Actual 1945-1946	Budget 1946-1947	Budget 1947-1948
PUBLICATION EXPENSE			
MECHANICAL ENGINEERING text pages	$ 37,313.15	$ 46,000.00	$ 40,000.00
Student copies	5,654.05	8,000.00	9,600.00
MECHANICAL ENGINEERING advertising pages	60,552.62	59,700.00	53,500.00
Student copies MECHANICAL ENGINEERING advertising pages			12,900.00
Membership list	5,529.41	10,000.00	7,000.00
Transactions	35,648.37	48,800.00	45,000.00
Preprints	3,145.91		7,000.00
Journal of Applied Mechanics	9,723.83		
Cumulative transactions index	200.00	200.00	200.00
Mechanical catalog	39,250.10	43,000.00	41,000.00
Cost of publications sold	39,249.59	40,000.00	44,000.00
Reserved for bad debts	100.00	100.00	100.00
Reserved for publications inventories	500.00	500.00	500.00
Reserved for Boiler Code	2,000.00		
TOTAL PUBLICATIONS EXPENSE	$238,867.03	$256,300.00	$260,800.00

BUDGET FOR THE YEAR 1947–1948

	Actual 1945–1946	Budget 1946–1947	Budget 1947–1948
OFFICE EXPENSE			
Salaries	$287,060.00	$301,000.00	$298,700.00
Special membership list	4,230.07		
Advertising commissions	43,802.37	40,000.00	37,500.00
Postage	9,743.33	10,000.00	10,500.00
Printed matter	14,473.12	11,000.00	12,900.00
Traveling	13,600.00	12,000.00	14,700.00
Collections and exchange	584.98	500.00	500.00
Telephone and telegraph	9,983.07	10,000.00	8,800.00
Insurance	1,581.32	1,500.00	2,100.00
Secretary's emergency expense	340.14	300.00	400.00
Rent	30,711.91	29,918.00	29,093.00
Stationery and supplies	11,604.07	11,000.00	10,800.00
Maintenance and repairs	2,081.87	1,600.00	1,700.00
Badges and certificates	2,853.73	2,000.00	2,000.00
Unclassified	7,452.64	4,730.00	4,840.00
Furniture and equipment	6,300.00	1,500.00	2,000.00
Space advertising	2,330.71	2,200.00	2,500.00
Audit Bureau expense	173.90	500.00	500.00
Service honorarium	400.00	500.00	700.00
TOTAL OFFICE EXPENSE	$449,307.23	$440,248.00	$440,233.00

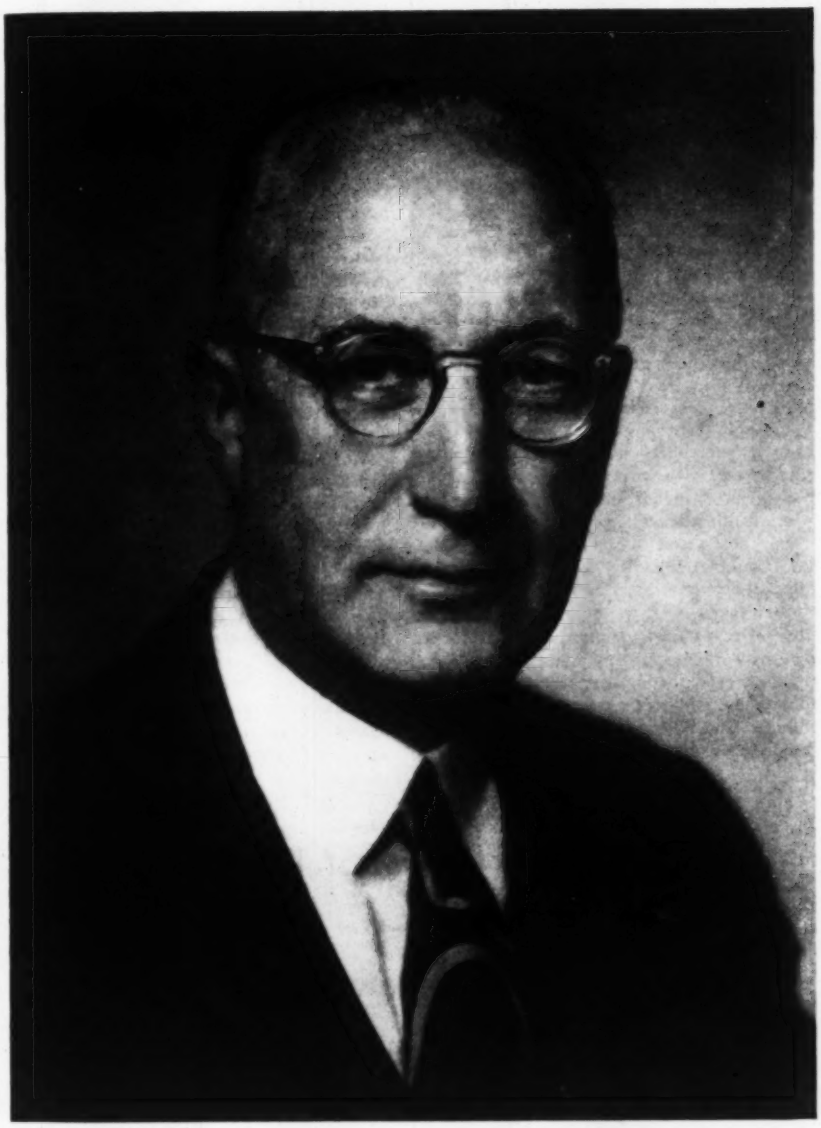
Strength and Behavior of Riveted Joints to Be Studied

STUDY of the strength and behavior of riveted and bolted joints, on which is dependent the endurance of steel structures such as bridges, is one of the latest projects to be sponsored by the Engineering Foundation, A. B. Kinzel, chairman of the board, announced recently at the Foundation's headquarters, 29 West 39th Street, New York, N. Y. The research is being carried on at the University of Illinois and at Northwestern University under the direction of a Research Council whose members represent the various interests concerned.

"Investigation of fatigue effects is now recognized as a necessity by engineers in designing structural parts which are subjected to repeated stress cycles, and additional information on how to accomplish this is urgently needed," Dr. Kinzel said.

COMBINED ANALYSIS OF EXPENDITURE BUDGET

	Under Committee Supervision					
	Joint bodies	Members travel	Others	Printing and distribution	Office expense	Totals
PUBLICATIONS, STANDARDS, CODES & RESEARCH						($448,283)
1 MECHANICAL ENGINEERING, text pages (excluding student copies)				$ 40,000	$ 23,039	63,039
2 MECHANICAL ENGINEERING, advertising pages (excluding student pages)				53,600	57,568	111,168
3 Transactions and *Journal of Applied Mechanics*			$ 200	52,200	14,916	67,316
3(a) Membership list				7,000	1,470	8,470
4 Mechanical catalog				41,000	41,348	82,348
5 Publication sales (except Standards, Codes, and Research Reports)				15,500	6,505	22,005
6 Standards and Codes	$ 1,000			25,000	55,041	81,041
7 Research				4,000	8,896	12,896
GENERAL SOCIETY ACTIVITIES						($193,900)
1 Society Meetings and publicity			23,000		18,413	41,413
2 Sections		$ 9,500	45,000		13,877	68,377
3 Professional Divisions			5,000		12,025	17,025
4 Student Branches (including copies of MECHANICAL ENGINEERING)		3,000	12,000	22,500	8,025	45,525
5 Admissions					15,199	15,199
6 Membership development					4,774	4,774
7 Awards			1,035		552	1,587
GENERAL SOCIETY ADMINISTRATION						($35,100)
1 Council		5,800	500			6,300
2 Professional services (Counsel, etc.)			2,500			2,500
3 Nominating Committee		2,000				2,000
4 Retirement Fund			23,800			23,800
5 "Know Your Society"			500			500
JOINT ACTIVITIES						($ 19,442)
1 Engineering Societies Library	11,242					11,242
2 E. C. P. D.	1,700					1,700
3 Engineers Joint Council	1,500					1,500
4 Engineering Societies Personnel Service, Inc. (Reserve)	2,000					2,000
5 Registration (National Council State Boards of Engineering Examiners)			500			500
6 U. E. T. Pension Fund	2,500					2,500
INDIRECT EXPENSE						($158,585)
1 Secretary's office					32,825	32,825
2 Accounting department					29,550	29,550
3 General service					59,617	59,617
4 General office					36,593	36,593
	$19,942	$20,300	$114,035	$260,800	$440,233	$855,310



E. G. Bailey

Nominated for President

A.S.M.E. OFFICERS *Nominated for* 1947–1948

DURING the Meeting of The American Society of Mechanical Engineers in Chicago, Ill., June 15–19, 1947, E. G. Bailey, vice-president, Babcock & Wilcox Company, New York, N. Y., was nominated by the National Nominating Committee for the office of President of the Society for the year 1947–1948.

Regional Vice-Presidents named by the Committee to serve two-year terms on the Council of the A.S.M.E. were Frank M. Gunby, Boston, Mass., Paul B. Eaton, Easton, Pa., Thomas E. Purcell, Pittsburgh, Pa., and J. Calvin Brown, Los Angeles, Calif. (renomination.)

Directors at Large named by the Committee to serve four-year terms on the Council were A. L. Penniman, Jr., Baltimore, Md., and William M. Sheehan, Eddystone, Pa.

Director at Large named by the Committee to serve a three-year term on the Council was Joseph B. Armitage, Milwaukee, Wis.

Members of the Committee making the nominations were: L. J. Hooper, Worcester, Mass., representing Region I; J. H. Sengstaken, New York, N. Y., representing Region II; R. C. Dannettel, Baltimore, Md., representing Region III; Prof. J. B. Jones, Blacksburg, Va., chairman, representing Region IV; J. G. Martin, Cincinnati, Ohio, representing Region V; Prof. Huber O. Croft, Iowa City, Iowa, representing Region VI; R. G. Roshong, North Hollywood, Calif., representing Region VII; and L. J. Cucullu, New Orleans, La., secretary, representing Region VIII.

Election of A.S.M.E. officers for 1947–1948 will be held by letter ballot of the entire membership, closing September 23, 1947.

Biographical sketches of the nominees follow on the succeeding pages.

Nominated for President

E. G. Bailey

ERVIN GEORGE BAILEY, who has been nominated to serve for one year as President of The American Society of Mechanical Engineers, was born at Damascus, Ohio, Dec. 25, 1880.

During his professional industrial life, Mr. Bailey has concentrated his attention on the efficient utilization of coal. Among his accomplishments is the development of a boiler meter as an aid to efficient combustion. This meter, now used all over the world, is built by the Bailey Meter Company which he founded. The development of a form of water-cooled furnace-wall construction, bearing his name and likewise used throughout the world, was another contribution to the conservation of coal.

In the fields of pulverized-coal firing and boiler and furnace design, he developed practical applications of the slag-tap furnace, the two-stage furnace, and open-pass boiler, intertube burners, pulverizers, and the direct firing of pulverized coal in high-capacity boilers, all of which designs are in common use today. He has also made important contributions to scientific coal sampling and to research in the behavior of coal ash.

Mr. Bailey, throughout his career, has been interested in the education of young men for the profession of engineering and he has exerted an important influence in that field. Among his papers are several dealing with the curricula and policy of engineering schools. He has been a member of the Board of Trustees of Lafayette College for several years. In the American Society for Engineering Education and the Engineers Joint Council his interest and leadership in the educational field have been a potent factor.

More than 100 patents have been issued in his name and he has passed his engineering knowledge along to others in the form of more than 35 technical papers and trade-paper articles. Except for an interim, he has served on A.S.M.E. Committees in various capacities since 1918.

Mr. Bailey obtained his mechanical-engineering degree at Ohio State University in 1903. He became interested in coal early in his college work, especially in its combustion and utilization in steam boilers. He was assistant, later chief, of the testing department of the Consolidation Coal Company, Fairmont, W. Va., 1903–1907, and from 1907 to 1909 was in charge of the coal department of Arthur D. Little, Inc., Boston, Mass. Recognizing the inadequacy of the existing methods of sampling and analyzing coal, he engaged in research on this subject, and in 1909 published his paper on "Coal Sampling" which later served as the basis of the procedure adopted by American and British engineers.

During the period of 1909–1915 in which he was mechanical engineer and partner in The Fuel Testing Company, Boston, Mass., he developed a boiler meter in which the steam-flow and air-flow pens recorded on the same scale, giving an instantaneous indication of steam output and excess combustion air. In 1916 he organized his own company, The Bailey Meter Company, to manufacture and sell the Bailey boiler meter, which is now widely used in boiler plants in America and abroad.

When pulverized-coal firing was extended to boilers, available pulverized-coal feeders were found inadequate. He developed a volumetric nonflooding feeder, which for the first time gave uniform controlled feed of pulverized coal to the burner. The initial installation was made in 1923 at the Brunot Island Station of the Duquesne Light Company, Pittsburgh, Pa. The Bailey Feeder still retains its superiority where pulverized coal is used in storage systems.

Automatic combustion control in boiler furnaces challenged his inventive ability about 1923. His system of combustion control has been improved steadily and is in general use throughout the country today.

Water cooling of the boiler furnace is now recognized to be a most important factor in modern high-capacity boiler units. Mr. Bailey played a pioneering part in its development. He designed the Bailey water-cooled furnace constructions which have been successful since the initial installation in 1924 at the East 70th Street plant of the Cleveland Electric Illuminating Company.

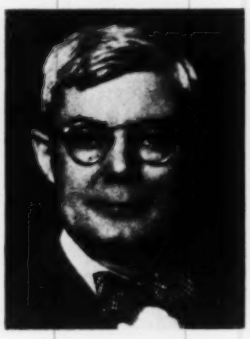
His water-cooled furnace, burner, and feeder business was acquired by The Babcock and Wilcox Company in 1926 for its subsidiary, The Fuller Lehigh Company. Mr. Bailey then became president of that company and in 1930 vice-president of The Babcock and Wilcox Company. The Fuller Lehigh Company was later merged with The Babcock and Wilcox Company.

Here, for the last 21 years, Mr. Bailey has devoted his inventive, developmental, and executive abilities to effecting improvements in the science of steam generation from the combustion of fuels.

Many academic honors and engineering awards have been conferred on Mr. Bailey. Among these are: doctor of engineering from Lehigh University, 1937; Ohio State University, 1941; doctor of science, Lafayette College, 1942. In 1930 Mr. Bailey received the Longstreth Medal of The Franklin Institute. In 1936 he received the Lamm Medal of Ohio State College. He was awarded the A.S.M.E. Medal of the Society in 1942 "for achievement and leadership in steam and combustion engineering." In that year also the Percy Nichols Award of the Fuels Division of the A.S.M.E. and the Coal Division of the A.I.M.E. was conferred on him. Mr. Bailey is one of the few American engineers who are honorary members of The Institution of Mechanical Engineers, London, England.

Nominated for Regional Vice-Presidents

To Serve Two-Year Terms



FRANK M. GUNBY

P. B. EATON

T. E. PURCELL

Frank M. Gunby

FRANK M. GUNBY, who has been nominated from Region I to serve for two years as Regional Vice-President of The American Society of Mechanical Engineers, was born in Charleston, S. C., in 1882. He was educated at Clemson Agricultural College, from which he received the degree of B.S. in 1902, and the honorary degree of M.E. in 1928.

Mr. Gunby served the Eagle & Phenix Mills in Georgia as draftsman and electrician until 1905, and since then continuously, except for the periods of World War I and II, he was employed by Dean & Main, later Charles T. Main, and now Chas. T. Main, Inc., of Boston, Mass. In the early years he acted in the capacity of electrical engineer but branched into general industrial work, designing plants, and making reports and appraisals for various kinds of industry and power situations. He has also done work in India, Argentina, Canada, and Mexico. At the present time Mr. Gunby is associate and director of Chas. T. Main, Inc.

He enlisted and was commissioned in the National Guard in Georgia and Massachusetts 1902–1907.

During World War I he was colonel in charge of engineering of the construction division of the Army which was responsible for all war construction in continental United States. In World War II he handled for his firm the architect-engineer work on large projects for troop housing, Ordnance Department, Chemical Warfare Service, and Air Corps, principally under the Corps of Engineers.

Mr. Gunby became a member of the A.S.M.E. in 1915. He served on various committees as a member of the Boston Section, and was chairman of the National Nominating Committee in 1927, and a member of the Medals Committee 1935–1938. He is also a member of the American Institute of Electrical Engineers, American Society of Civil Engineers, Society of American Military Engineers, a past-president of the Boston Society of Civil Engineers, past-chairman, Engineering Societies of New England, member of the National Association of Cotton Manufacturers, American Institute of Consulting Engineers, and was representative on the American Engineering Council.

Paul Burns Eaton

PAUL BURNS EATON, who has been nominated from Region III to serve a two-year term as Regional Vice-President of The American Society of Mechanical Engineers, was born in Scranton, Pa., May 31, 1888. Following his graduation from Cornell University in 1911 he remained at the University as instructor in mechanical engineering until 1915. During the summer of 1912 he served as assistant engineer for the Canadian Tap and Die Company, Galt, Ontario, Can., and the following summer with the Dominion Bridge Company, LaChine, Province of Quebec, Can.

In 1915 Professor Eaton left the United States for China where he headed the department of mechanical engineering at the Chinese Government Engineering College, Tangshan, China. For distinguished services in this capacity, Professor Eaton was awarded the Decoration of the Chia Ho of the Chinese Government. Following declaration of war by the United States against the Central Powers, Professor Eaton returned home to serve with the Steel Ship Division of the U. S. Shipping Board, Baltimore, Md.

In 1924, following a year at The Pennsylvania State College, he joined the faculty of Lafayette College as assistant professor of mechanical engineering. Three years later he was promoted to associate professor and in 1931 to head of the department of mechanical engineering in which capacity he has served Lafayette College ever since. In addition to his teaching duties, Professor Eaton has undertaken an extensive consulting practice.

Well known among Chinese engineers, he was sent to China in 1943 as a special emissary of the U. S. Department of State. Since 1944 Professor Eaton has been adviser to the Ministry of Communications of the Chinese Republic.

During World War II, as consultant to the Armed Forces and the Department of State, he aided in setting up the program for specialized war-training courses.

Professor Eaton has long been active in the offices of The American Society of Mechanical Engineers. A member of the "Old Guard" of the A.S.M.E. Anthracite—Lehigh Valley Section, speaker in 1939 of the National Regional Delegates Conference, and member of the Committee on Relations With Colleges in 1940, Professor Eaton has also served for two years as a member of the A.S.M.E. Council, an office he resigned when he was called upon to undertake the mission to China.

Professor Eaton is active in many professional and learned societies. Among these are: American Association of University of Professors, American Society for Engineering Education, Engineers' Club of the Lehigh Valley, The Newcomen Society, Tau Beta Pi, and Pi Tau Sigma. He is a member of the Kiwanis Club of Easton, Pa., and has served as chairman of many local civic and religious groups.

Thomas E. Purcell

THOMAS EDWARD PURCELL, who has been nominated from Region V to serve for two years as Regional Vice-President of The American Society of Mechanical Engineers, was born October 25, 1889, in Rochester, N. Y., attended grade and high school in East Bloomfield, N. Y., and technical school in Buffalo, N. Y. He entered the test department of the General Electric Company at Schenectady, N. Y., in 1910, and while there assisted in the development of electric ship propulsion, particularly as adapted to the original installation, the U.S.S. Collier-Jupiter. In 1912, he entered the engineering department of the New York district office of the General Electric Company, remaining there until early in 1917 when he entered the United States Army as a second lieutenant in the Coast Artillery Corps. In 1918 he was discharged from his commission in the Army by the Secretary of War, to take up the duties of assistant turbine engineer at the Erie Works of the General Electric Company, Erie, Pa., where a large development for the production of steam-turbine propulsion equipment for the United States Navy destroyers was being undertaken. In 1919, when this work was completed, he returned to the New York district engineering department of the General Electric Company, specializing in development of large turbogenerators, remaining there until 1922. In 1923 he was engaged by Dwight P. Robinson & Company, New York, N. Y., as a design engineer, moving on to Pittsburgh, Pa., in 1925 to become general superintendent of power stations of the Duquesne Light Company, and general superintendent of the Allegheny County Steam Heating Company.

He is active in A.S.M.E. affairs, at the present time being a member of the Subcommittee on Model Smoke Law, Fuels Committee; a member of Committee No. 6 on Steam Turbines, Power Test Codes Committee; and a member of the Standing Committee on Power Test Codes. He held the post of vice-president in 1942–1943 and is a past vice-chairman of the Subcommittee No. 6 of the Joint Research Committee on Boiler Feedwater Studies, and is a past-secretary of the Executive Committee of the A.S.M.E. Pittsburgh Section.

Other technical organizations in which he holds membership are the Engineers' Society of Western Pennsylvania, the National District Heating Association of which he is a past-president, the Power Generation Committee of the Association of Edison Illuminating Companies, the Prime Movers Committee, Edison Electric Institute, the Smoke Prevention Association of America, and he represents the electric light and power group on Committee D-5 of the American Society for Testing Materials.

Mr. Purcell has written many technical articles on matters pertaining to the steam and electric utility fields and has produced several inventions in those fields.

Renominated for Vice-President

To Serve Two-Year Term

J. Calvin Brown

J. CALVIN BROWN

J. CALVIN BROWN, renominated for the office of Regional Vice-President of The American Society of Mechanical Engineers, attended public and high schools in Los Angeles, and the California Institute of Technology.

He studied law at Hamilton College where he received the degrees of L.L.B. and L.L.M. He also attended special courses at Southwestern University and the University of Southern California.

Mr. Brown is an attorney at law and mechanical engineer, specializing in patent, trademark, and copyright litigation before the United States Courts. He is a member of the bars of the U. S. Supreme Court and of the highest courts, both State and Federal, in

California, Illinois, and the District of Columbia.

He became a member of the Society in 1928 and was chairman of the Entertainment Committee at the A.S.M.E. Semi-Annual Meeting in Los Angeles, Calif., in 1938. He was chairman of the Southern California Section from 1941 to 1943; chairman of the Nominating Committee, Southern California Section, in 1944 and 1945, general chairman of the A.S.M.E. Semi-Annual Meeting in Los Angeles in 1943, a Manager of the Society in 1943 and 1944, and Vice-President 1946–1947. He was general chairman of the War Production Board Meeting in Los Angeles in 1943.

Mr. Brown is past-president of the Los Angeles Engineering Council of Founder Societies; past-chairman, Los Angeles Bar Association, Patent Section; past-president, Los Angeles Patent Law Association, and a member of the various sections of the American Patent Law Association, The American Bar Association, and California State Bar Association; vice-president of the Adventurers Club; an active member of the Society of Motion Picture Engineers, Society for the Advancement of Science, member, Water and Power Resources Committee, and of various social clubs in and around Los Angeles, including Town Hall. He was chairman of Engineers, 7th War Loan Drive, and an appeal agent of the Selective Service System.

Nominated for Directors at Large

To Serve Four-Year Terms

A. L. PENNIMAN, JR.

W. M. SHEEHAN

A. L. Penniman, Jr.

ABBOTT LAWRENCE PENNIMAN, JR., who has been nominated for the office of Director at Large of The American Society of Mechanical Engineers, was born February 12, 1892, at Bel Air, Harford County, Maryland. He received his academic education at Bel Air Academy and the Baltimore Polytechnic Institute.

He first became associated with the Consolidated Gas Electric Light and Power Company of Baltimore in 1911 serving initially as a draftsman, then as a testman, and later as an inspector in the electric division. From 1914 to 1937 he was superintendent of steam-electric generating stations, in charge of plant operations, maintenance programs and economic studies in connection with old and new equipment. During this time he was largely instrumental in directing the engineering development and construction activities of his company, particularly in the power-plant field. Since 1937, as general superintendent, electric operations, he has had general supervision of design, construction, operation and maintenance of all electric property of the company.

As a licensed professional engineer in the states of Maryland, New York, and New Jersey, Mr. Penniman has lent his technical ability and engineering knowledge to consulting work for many years. He has been interested in and contributed to the design of various types of engineering equipment. He has developed many new methods to improve apparatus in existing power plants and has been responsible for a great number of new plant evolutions. His work along this line has resulted in his having been granted numerous patents and has gained him recognition as one of the outstanding power-plant engineers in the United States.

Mr. Penniman was admitted to The American Society of Mechanical Engineers in 1915. He became a member in 1932 and a Fellow in 1946. He participated in many of the activities of the Society during this time, both national and in the A.S.M.E. Baltimore Section. During 1923 and 1924, he served as chairman of the Section, and has recently served as chairman of its Program Committee. A few years ago he was a member of the Budget Committee of Council.

He is a fellow of the American Institute of Electrical Engineers, and a member of the American Society of Naval Engineers, Maryland Society of Professional Engineers, Naval Institute, and Army Ordnance Association. He also serves as a member of the Maryland State Board of Boiler Rules and is the engineering member of the Maryland State Board of Health.

At present, his technical-committee work comprises the following assignments: Chairman of the Committee on Power Generation, Association of Edison Illuminating Companies; member of the A.S.M.E. Boiler Code Committee; member of Engineering Division General Committee, Edison Electric Institute; A.E.I.C. representative on Sectional Committee, Code for Pressure Piping of the American Standards Association; and a member of Public Utility Advisory Committee to Welding Research Committee, American Welding Society.

He is a member of the Maryland Academy of Sciences and the American Association for the Advancement of Science. In 1940 a Committee of Scientists, under the direction of Dr. Karl T. Compton, selected Mr. Penniman, because of his interest in new developments of a scientific nature and his work in this field, to receive a Special Award as one of this country's Modern Pioneers.

Mr. Penniman has given generously of his time, energy, and knowledge to advance the professional standing of the engineer and, through natural engineering ability, has been instrumental in accelerating technological developments by combining the use of basic fundamentals with good judgment.

W. M. Sheehan

WILLIAM MARK SHEEHAN, who has been nominated for the office of Director at Large of The American Society of Mechanical Engineers, was born in Roanoke, Va., on April 25, 1887. He received his early education at St. Andrew's School in Roanoke and later attended St. Louis University.

He served an apprenticeship as machinist with the Norfolk and Western Railway Company and was also employed in the engineering departments of American Locomotive Company, Erie Railroad, New York Air Brake Company and Keith Car & Manfacturing Company until he entered the service of the Commonwealth Steel Company at Granite City, Ill., December 1, 1913.

Mr. Sheehan has since been continuously with Commonwealth Steel Company and its successor, General Steel Castings Corporation. He has been successively: Assistant mechanical engineer, sales engineer, and assistant vice-president until June 22, 1945, when he was elected vice-president of General Steel Castings Corporation. He has taken a prominent part in the design and development of one-piece cast-steel beds and trucks for railway locomotives and cars, and many patents in this connection have been issued to him.

Mr. Sheehan is a Fellow of The American Society of Mechanical Engineers. He became a member in 1920. He has been active in the Railroad Division of the Society, having served on its programs, membership, general and executive committees, and as Division chairman in 1945. He served also on the Standing Committee on Professional Divisions, becoming its chairman in 1944. For several years he has been on the Committee on Membership Development and is its chairman for 1947. He was selected in 1943 by the Standing Committee on Professional Divisions to

head the re-organization of the Metals Engineering Division.

He is also a member of the American Society for Engineering Education; American Institute of Mining and Metallurgical Engineers; The American Foundrymen's Association; the Army Ordnance Association; Newcomen Society of England, and The Franklin Institute of Philadelphia. His club affiliations are: The Engineers Club of Philadelphia, Merion Golf Club, Railroad Machinery Club of New York, and the Canadian Club of New York.

During World War II Mr. Sheehan was actively engaged in the design of cast-armor hulls and turrets for combat tanks for the United States, Canadian, and British Governments. During this period he served as a member of the War Production Committee of the A.S.M.E.

For five months (1946–1947) Mr. Sheehan was absent from the country on a mission for General Steel Castings Corporation to South Africa in connection with the application of American railway mechanical-engineering practice to the rolling stock of the South African Railways. He is currently in Great Britain on a similar mission.

Nominated for Director at Large

To Serve Three-Year Term

Joseph B. Armitage

JOSEPH BRADLEY ARMITAGE, who has been nominated for the office of Director at Large of The American Society of Mechanical Engineers, was born at Hyde, Cheshire, England, on April 10, 1881. He received his early education in England and completed it in the United States. In 1900 he became an apprentice draftsman with Brown & Sharpe Manufacturing Company, Providence, R. I. In 1904 he entered Rhode Island State College. He returned to the Brown & Sharpe Mfg. Company three years later as assistant designer, and from there he went with Taft-Peirce Manufacturing Company, Woonsocket, R. I., as machine designer. In 1910 he was chief draftsman for the Narragansett Machine Company, and in 1918 mechanical engineer in the Lynite Laboratory of Aluminum Castings Company, Cleveland, Ohio. In 1920 he was appointed chief engineer of the Kearney & Trecker Corporation, Milwaukee, Wis. He is at present vice-president in charge of engineering of that corporation. Mr. Armitage joined the A.S.M.E. as a member in 1919, and only this year was made a fellow of the Society.

J. B. ARMITAGE

He is also a member of the Society of Automotive Engineers, Milwaukee Engineering Society, Newcomen Society (American Branch), past-chairman Milwaukee Section of the S.A.E., and past-director of the Milwaukee Engineering Society. His club affiliations include the Milwaukee Yacht Club, South Shore Yacht Club, Milwaukee, United States Power Squadrons, Shriner (Tripoli Temple), K.T., 32nd degree Mason.

A.S.M.E. 1948 Nominating Committee Organizes

SELECTED at the 1947 Semi-Annual Business Meeting of The American Society of Mechanical Engineers, Chicago, Ill., June 16, 1947, the 1948 Nominating Committee at its organization meeting chose R. W. Flynn, Gulf Oil Corporation, New York, N. Y., as chairman, and H. L. Solberg, Purdue University, Lafayette, Ind., as secretary.

Arrangements were made for a preliminary meeting of the committee at the 1947 Annual Meeting, Atlantic City, N. J., and for the executive meeting at which nominations of Society officers will be made, in Milwaukee, Wis., during the 1948 Semi-Annual Meeting of the Society.

The 1948 National Nominating Committee is composed of the following:

REGION I: Lester C. Smith, Spencer Turbine Company, Hartford 6, Conn.; James A. Powell, Stone & Webster Engineering Company, 49 Federal St., Boston 7, Mass., 1st Alternate; T. A. Fearnside, Stone & Webster Engineering Company, 49 Federal St., Boston 7, Mass., 2nd Alternate; and E. A. Harrington, 1500 Turks Head Building, Providence, R. I., 3rd Alternate.

REGION II: R. W. Flynn, chairman, Gulf Oil Corporation, 17 Battery Place, New York 4, N. Y.; H. C. R. Carlson, Charles Fischer Spring Company, 749 Atlantic Ave., Brooklyn, N. Y., 1st Alternate; and H. R. Kessler, Republic Flow Meters Corporation, 420 Lexington Ave., New York, N. Y., 2nd Alternate.

REGION III: F. S. Erdman, College of Engineering, Cornell University, Ithaca, N. Y.; P. C. Osterman, 19 Stile Street, Elizabeth 3, N. J., 1st Alternate; H. H. Snelling, Snelling and Hendricks, 900 F St., N. W., Washington 4, D. C., 2nd Alternate.

REGION IV: Paul R. Yopp, Babcock and Wilcox Company, 1203 Candler Bldg., Atlanta 3, Ga.; S. B. Earle, School of Engineering, Clemson College, S. C., 1st Alternate; and L. G. Haller, Tennessee Eastman Corporation, Kingsport, Tenn., 2nd Alternate.

REGION V: H. S. Colby, Malleable Founders Society, 1800 Union Commerce Building, Cleveland 14, Ohio; D. S. Brown, Cincinnati Gas and Electric Company, 4th & Main Streets, Cincinnati 2, Ohio, 1st Alternate; and Paul R. Duffey, Youngstown Sheet and Tube Company, Youngstown, Ohio, 2nd Alternate.

REGION VI: H. L. Solberg, secretary, Purdue University, Lafayette, Ind.; B. H. Jennings, Technical Institute, Northwestern University, Evanston, Ill., 1st Alternate; and W. Lyle Borst, Power Service Corporation, 711 Wesley Temple Building, Minneapolis 4, Minn., 2nd Alternate.

REGION VII: D. A. Elkins, U. S. Bureau of Mines, 1600 E. 1st South, Salt Lake City, Utah; Colonel Fairman B. Lee, 117 Garfield St., Seattle 9, Wash., 1st Alternate; and B. G. Dick, Department of Interior, Bonneville Power Administration, 1300 N. E. Union Ave., Portland, Ore., 2nd Alternate.

REGION VIII: Orval L. Lewis, Jones and Laughlin Supply Company, 108 N. Trenton, Tulsa 2, Okla.; A. A. Woodward, Steam Production, Public Service Company of Colorado, 900-15th St., Denver 2, Colo., 1st Alternate; and H. B. Atherton, Kansas City Power and Light Company, 1330 Baltimore Ave., Kansas City 1, Mo., 2nd Alternate.

W.E.C. Council to Meet in Zurich, Switzerland, Sept. 10-11, 1947

THE council of the World Engineering Conference, comprising delegates of national committees participating in the W.E.C., will meet in Zurich, Switzerland, Sept. 10 and 11, 1947.

Among matters to be discussed are possible modification of the W.E.C. constitution, relationship of UNESCO to W.E.C., and determination of the date and program of the next international technical congress.

American engineers will be represented at Zurich by Fenton B. Turck, member A.S.M.E., and member E.J.C. Committee on International Relations. Mr. Turck is also a member of the W.E.C. council and was one of the American engineers who took part in setting up the organization at the International Technical Congress in Paris, Sept. 16 to 19, 1947.

Membership in the W.E.C. is by national committees composed of all engineering societies and organizations in each country.

An account of the organization of the World Engineering Congress is given in Mr. Turck's article, "The American Stake in World Engineering," published on pages 142 to 144 in the February, 1947, issue of MECHANICAL ENGINEERING.

THE U. S. STEEL'S GENEVA STEEL PLANT NEAR PROVO, UTAH, LOOKING ACROSS THE 312-ACRE LAKE BUILT FOR COOLING PURPOSES

Tentative Program of the A.S.M.E. 1947 Fall Meeting, Salt Lake City, Utah Sept. 1 to 4, 1947

THE industrial achievements of Utah and particularly of its capitol, Salt Lake City, which is currently celebrating the centennial anniversary of its founding, will provide the background and theme of the A.S.M.E. 1947 Fall Meeting to be held at Hotel Utah, Salt Lake City, Utah, Sept. 1 to 4, 1947.

Originally it had been planned to conduct an A.S.M.E. National Parks Tour to arrive at Salt Lake City in time for the meeting, but because of a lack of interest among members, this event has been canceled.

Technical sessions have been planned on the following subjects: Metals engineering, education, management, hydraulics, fuels, power, and applied mechanics.

The social events will include luncheons, dinners, the banquet, and special events for the wives and guests of members attending the meeting.

At the banquet on Wednesday, Sept. 3, John Knudsen Northrop, president and chief engineer, Northrop Aircraft, Inc., Hawthorne, Calif., will receive the A.S.M.E. Spirit of St. Louis Medal in recognition of his contributions to aviation and especially for his design of the flying wing.

The program of technical sessions provides ample time for visits to the many natural and industrial show places around Salt Lake City. These trips include visits to the Bingham Copper Mine, Geneva Steel Plant, and the ore-concentrating mills at Magna, Utah. Other trips will be made to near-by canyons where many things of geological interest may be seen.

The tentative program follows:

MONDAY, SEPTEMBER 1

8:00 a.m.

Registration

12:15 p.m.

Luncheon Meeting

Speaker: Eugene W. O'Brien, president A.S.M.E., vice-president, W. R. C. Smith Publishing Company, Atlanta, Ga.

2:30 p.m.

Metals Engineering

Research Work on Rail Sections, by Walter Leaf, research technician, The Denver and Rio Grande Western Railroad Company, Denver, Colo.

Abrasion Resistance of Alloyed White Cast Iron, by Kenneth A. DeLonge, The International Nickel Company, New York, N. Y.

Bend-Strength Characteristics of Commercial Cemented Tungsten Carbide, by L. S. Foster, chief, powder-metallurgy branch, Watertown Arsenal, Watertown, Mass.

2:30 p.m.

Education

Developing Leadership in Technically Trained and Experienced Engineers

Speakers: Panel of 3 or 4 men from near-by industries.

6:15 p.m.

Dinner Meeting

Speaker: to be announced

8:15 p.m.

Management

Increased Productivity and Economic Stability Through Methods Improvement

Methods Engineering—Common Sense Systematically Applied, by Harry T. Schwan, Manager, Midwestern division, Methods Engineering Council, Kansas City, Mo.

Top Management's Role in Methods Improvement, by Huston E. Turpin, president, Neevel Manufacturing Company, Kansas City, Mo.

Industrial Lighting Projects by the Illuminating Engineering Society, by Walter Sturrock, illuminating engineer, General Electric Company, Nela Park, Cleveland, Ohio

Motion Pictures

Special showing of the kodachrome films "Fido" (Fog Investigation Dispersal Operations) and "Pluto" (Pipe Line Under the Ocean) which describe British operations during World War II. The films are spectacular and well worth seeing.

TUESDAY, SEPTEMBER 2

8:00 a.m.

Registration

9:30 a.m.

Materials Handling

Handling Bulk Material Mechanically, by L. J. Carson, chief engineer, Link Belt Company, Pacific Division, San Francisco, Calif.

Hydraulics

The 103,000-Hp Turbines at Shasta Dam, by J. F. Roberts, manager, hydraulic department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Temporary Installation of Shasta Turbines at Grand Coulee, by Herbert H. Sloane, engineer, department of design and construction, Bureau of Reclamation, Denver, Colo.

12:15 p.m.

General Luncheon

Newhouse Hotel

Speaker: to be announced

2:30 p.m.

Inspection Trip

Bingham Open-Pit Copper Mine, Utah Copper Division, Kennecott Copper Corporation, Bingham, Utah

6:15 p.m.

Joint Dinner With Utah Section A.I.M.E.

Speaker: Dr. Clyde E. Williams, president A.I.M.E., director, Battelle Memorial Institute, Columbus, Ohio. Subject: Materials for Powering the Future.

WEDNESDAY, SEPTEMBER 3

9:30 a.m.

Applied Mechanics

Square Plates Fixed at Points, by C. J. Thorne, Professor, University of Utah, Salt Lake City, Utah.

Fuels

Continuous-Discharge Spreader Stoker, by Otto de Lorenzi, director of Education, Combustion Engineering Company, Inc., New York, N. Y.

Looking to Increased Efficiency in Burning Utah Coals—An Activity of the Utah Coal Operations Association, by J. F. Heath, fuels engineer, Utah Coal Operators Association, Salt Lake City, Utah

12:15 p.m.

Joint Luncheon

Sons of the Utah Pioneers

Speaker: Dr. O. Meredith Wilson, dean of the School of Arts and Sciences, University of Utah, Salt Lake City, Utah

2:30 p.m.

Inspection Trip

Geneva Plant of the United States Steel Corporation near Provo, Utah

6:15 p.m.

Banquet

Speaker: To be announced

THURSDAY, SEPTEMBER 4

8:00 a.m.

Registration

ONE OF THE BLAST FURNACES AT THE GENEVA STEEL PLANT NEAR PROVO, UTAH

9:30 a.m.

Power

Spreader Stoker (motion picture), by Otto de Lorenzi, director of education, Combustion Engineering Company, Inc., New York, N. Y.

Spreader Stokers, by R. L. Beers, vice-president, charge of engineering, Detroit Stoker Company, Detroit, Mich.

Steam-Electric Generating Station for Kennecott Corporation, Utah Copper Division, by G. A. Parker, assistant mechanical engineer, Control Power Station, Utah Copper Company, Salt Lake City, Utah

Process Industries

Respiration Heat Problems of Sugar-Beet Storage, by R. D. Barmington, associate research engineer, Colorado Agricultural Experiment Station, Colorado A. & M. College, Ft. Collins, Colo.

12:15 p.m.

Joint Luncheon With the Kiwanians

2:30 p.m.

Inspection Trips

Geology Tour by bus to near-by canyons

Visit to Garfield Smelter and Magna Flotation Mill and Power Plant

C. R. Soderberg Promoted at M.I.T.

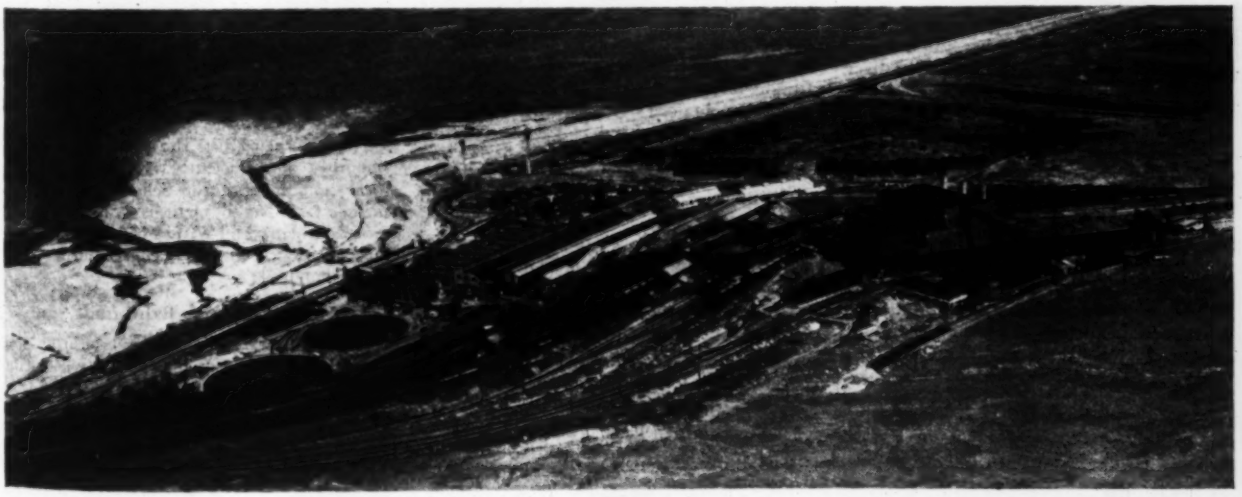
THE appointment of C. Richard Soderberg, member A.S.M.E., as head of the department of mechanical engineering at the Massachusetts Institute of Technology was announced by Karl T. Compton, member A.S.M.E., president of the Institute. Professor Soderberg's appointment will permit Jerome C. Hunsaker, honorary member A.S.M.E., who has been head of both the departments of mechanical and aeronautical engineering since 1933, to devote his entire attention to direction of the Institute's rapidly expanding program of research and instruction in aeronautical engineering, a field in which he is widely recognized as an authority.

Petroleum Proceedings Available

THE Proceedings of the 1946 National Conference on Petroleum Mechanical Engineering held at Tulsa, Okla., under the sponsorship of the Petroleum Committee of the A.S.M.E. Process Industries Division, have been published in the form of a 220-page 11 × 8½-in. paper-bound volume containing 36 papers and more than 300 illustrations.

The papers cover the mechanical problems of the petroleum industry under five headings: Applications, construction materials, production, refining and equipment, and transportation.

The Proceedings will be mailed soon to all registrants at the 1946 Conference. Extra copies may be obtained from A.S.M.E. Publication Sales, 29 West 39th St., New York 18, N. Y. The price is $4.50 per copy.



PANORAMA OF THE CONCENTRATING MILLS AT MAGNA, UTAH, ONE OF THE PLANTS TO BE VISITED BY MEMBERS ATTENDING THE A.S.M.E. 1947 FALL MEETING IN SALT LAKE CITY, UTAH, SEPT. 1 TO 4, 1947

A.S.M.E. Applied Mechanics Division Holds Thirteenth Annual Conference

ATTRACTED by an ambitious technical program, over one hundred and fifty members and guests of The American Society of Mechanical Engineers gathered in Schenectady, N. Y., on June 23–25, 1947, for the Thirteenth Annual Conference of the A.S.M.E. Applied Mechanics Division. With the A.S.M.E. Schenectady Section and Union College as hosts, a stimulating program was arranged which included, in addition to the technical sessions, a banquet and a trip through the General Electric plant. The climax of the plant inspection was a visit to the General Electric House of Magic.

The technical program included 23 papers which were presented in five sessions. Their scope ranged from problems in structures, elasticity, dynamics, and hydraulics to discussions dealing with the supersonic flow through turbines and compressors. Dr. Carter Davidson, president of Union College, was the chief banquet speaker and his address was the high light of the meeting. Technical sessions were held on the campus of Union College, and the beautiful surroundings and pleasant weather added much to the enjoyment of the meeting.

A STUDY IN TURBINE WHEELS

Significance of Words

Dr. Davidson chose for his theme "Education and Specialization." Pointing out clearly the difference between "training" and "education," he said that all too often the two are taken to be synonymous. Actually, a trained man, who has mastered certain prescribed techniques and memorized pertinent facts, is far divorced from the educated worker whose broad background and wide experience qualifies him for thoughtful advance in his field. The reason that paradoxes such as this arise, said Dr. Davidson, is due to our laxity in defining the meaning and significance of everyday words. As a further example of confusions which arise from careless use of words, Dr. Davidson pointed out that the man of great "reputation" in his field is not necessarily the person whose knowledge makes him qualified to be a leader, and that the common fallacy of confusing "importance" with "size" is met on every hand.

Pursuing his subject further, Dr. Davidson investigated the qualities of a number of books which have widely influenced American thought and action. Stressing the fact that many of these books are not literary masterpieces, he discussed the reasons for their impact on American society. In conclusion, Dr. Davidson summed up his thesis by stating that the future of our society rests on careful analytical thought on the part of our people, in order that confusions would not overcome our striving toward a better community.

Included in the first technical session were five papers, two of which were presented by title only. G. D. McCann and J. M. Kopper of the California Institute of Technology spoke on "Generalized Vibration Analysis by Means of the Mechanical Transients Analyzer," while R. C. Binder and A. S. Hall, Jr., of Purdue University, presented an analytical method for studying the gas vibrations in engine manifolds. Miss Alice Winzer of Brown University, spoke on "The Mobility Method Applied to Mechanical Wave Filters with Inductive Coupling." Interest in this session was heightened by Miss Winzer's delivery, for this represented the first paper presented to the Division by a woman.

Invention in Engineering

The first paper of the second session departed somewhat from the technical side of engineering. D. W. McLenegan presented an analysis of the place of invention in engineering development, and his paper was discussed avidly by many of his associates at the General Electric Company. Mr. McLenegan's paper is published on pages 661 and 662 of this issue. M. A. Sadowsky and E. Sternberg then presented the results of a detailed and complicated study on the stresses about an ellipsoidal cavity in an elastic solid, and L. H. Donnell who is associated with these authors at the Illinois Institute of Technology, outlined how the results obtained by Messrs. Sadowsky and Sternberg are to be used in connection with a broader program dealing with the fracture of metals.

Continuing the second session, J. T. Burwell from the Massachusetts Institute of Technology described the results of a study aimed at the development of a method for calculating the performance of loaded sleeve bearings under very general conditions of dynamic loading. Finally, in a unique joint presentation, V. Rojansky of Union College and R. A. Beth of Western Reserve University, presented a shortened method for designing beam columns.

Strain and Plastic Deformation

The third session was devoted to papers dealing with the strength properties of materials. The first of the four papers was delivered by W. R. Osgood of the David Taylor Model Basin, wherein he described the results of combined-stress tests on 24S-T aluminum-alloy tubes. E. P. Popov, of the University of California, then discussed a method for correlating tension-creep tests with relaxation tests. J. H. Hollomon and J. D. Lubahn of the General Electric Company, next delivered their paper "Derivation of Stress, Strain, Temperature Strain-Rate Relation for Plastic Deformation," which was followed by a paper by J. Marin of the Pennsylvania State College, and F. B. Stulen, Curtiss-Wright Corporation, dealing with a new fatigue strength - damping criterion for the design of resonant members.

Fluid-Flow Problems

The fourth session on Wednesday morning was devoted to papers dealing with fluid-flow problems. C. Concordia and G. K. Carter of the General Electric Company, presented the results of an interesting study in which they used a d-c network analyzer to determine the flow pattern through an idealized centrifugal impeller. A. Vaszonyi of North American Aviation, followed with an interesting discussion of a new procedure for designing blade cascades based on the repeated use of the method of conformal transformation. G. F. Carrier of Brown University, then discussed the design of an ideally efficient elbow for the purpose of accelerating the flow of a fluid stream, and the session was concluded with a description by R. C. Binder of Purdue University, of his researches directed toward the development of a method to enable the calculation of diffuser efficiencies.

The final session of the meeting commenced with a discussion of "Polar Strain" by C. W. Harris of the Goodrich Company. Mr Harris' paper dealt with the design of springs, formed by filling the void between two concentric cylinders with an elastometer. H. Poritsky, C. W. Hewlett, Jr., and R. E. Coleman, Jr., of the General Electric Company, then presented their paper "Theoretical Considerations in Calculating Sliding Friction of Ball Bearings of the Pivot Type." Problems concerned with the design of towing cables or loops were next discussed by L. Landweber and M. H. Protter of Brown University, and the session was concluded with the presentation of two papers by title, submitted by authors from England.

Particular credit is due to the members of the A.S.M.E. Schenectady Section for their careful guidance and co-ordination of the meeting.

Through their efforts, the meeting functioned smoothly and efficiently. Members of the local committee of the Schenectady Section include A. J. Nerod, chairman; N. P. Bailey, vice-chairman; and W. L. Fleischmann, secretary. C. Concordia was in charge of the Meetings Committee.

Early Books Exhibited

An interesting addition to the meeting was the exhibition of a number of early scientific books drawn from the collection of Prof. M. F. Sayre of Union College. The extensive collection of Professor Sayre includes many volumes whose publication represented the early efforts in the classical sciences, and their text appeared in interesting contrast to the papers delivered at the technical sessions.

Reported by MARTIN GOLAND.

Advances in Wood Technology Discussed at A.S.M.E. 1947 Wood Industries Conference

THE 1947 Wood Industries Conference of The American Society of Mechanical Engineers was held at the Loraine Hotel, Madison, Wis., June 12 and 13, 1947. Co-sponsored by the A.S.M.E. Rock River Valley Section and the U. S. Forest Products Laboratory, Madison, Wis., the Conference was attended by 112 engineers of the wood industries. All technical sessions were well attended.

D. W. Nelson, professor, college of engineering, University of Wisconsin, was general chairman. He was assisted by C. B. Norris, chairman (reception and technical sessions); C. A. Gilpin (dinner); J. T. Drow (registration); J. S. Mathewson (transportation); and W. J. Baker (Forest Products Laboratory inspection trip). The general arrangements of the meeting reflected careful planning on the part of the Conference committees.

Plans were made for an inspection trip in Chicago on Monday, June 16, to visit the plants of the Onsrud Machine Works and the Ed. Roos Company. J. W. Kendrick and H. K. von Maltitz, who attended the Madison meetings, made the arrangements.

The afternoon of Thursday was given over to an inspection trip through the Forest Products Laboratory, under the chairmanship of Wm. J. Baker. Three groups of twenty each were escorted through the various shops and workrooms of the laboratory. The laboratory staff also co-operated in making the technical sessions successful, supplying recorders and aides, as well as entering actively into the discussions.

A meeting was held by the Forest Protection Committee, headed by R. B. Sargent, co-chairman, of The American Society of Mechanical Engineers, and David P. Godwin of the Society of American Foresters, in which definite steps were taken for an aggressive program of co-operation. The meeting was the last official act of Mr. Godwin, who died the next day in an airplane crash en route to Washington, D. C.

Shrinkage of Wood

The program on Thursday morning included three papers, one by Robert A. Cockrell, professor, school of forestry, University of California, on "Longitudinal Shrinkage of Wood," in which he advanced a demonstrable theory accounting for this phenomenon in certain western species. A technical background for "Lumber Grading, Inspection, and Specification" was presented by L. W. Smith, wood technologist of the U. S. Forest Service at Washington, D. C. It presented a clear perspective of the value of standards in procuring the most desirable and least costly types of lumber for a given purpose. An engineer himself, who has given many years to government service, he was able to give his message in an effective manner. The third paper on "High-Frequency Electrical Heating" was co-authored by W. H. Hickox of the Thermex Division of the Girdler Corporation, Louisville, Ky., and W. B. Wilkins, consulting engineer of Ridgewood, N. J. The subject proved to be quite provocative and an active discussion was cut short by the lunch hour. This electrostatic method of rapidly curing resin adhesives holds distinct promise and is attracting the interest and attention of progressive woodworkers.

Division Honors T. D. Perry

At the banquet on Thursday evening, C. B. Lundstrum of Little Falls, N. Y., presided. He introduced L. J. Markwardt, assistant director of the Forest Products Laboratory.

The address of welcome was by F. W. Gottschalk, technical director of the American Lumber & Treating Company, who spoke in behalf of the Forest Products Research Society, of which he has recently been elected president. This society is a co-ordinating organization to channel wood-research projects without overlapping, to codify the resulting reports, and to encourage co-operative work within the whole field of forest-products industries. During the introductory speeches Thomas D. Perry was presented with a silver inscribed gavel, as a mark of appreciation for his 25 years of service in the A.S.M.E. Wood Industries Division. R. J. Seidl, of the Forest Products Laboratory staff, gave an interesting talk on the "Wood Industries of Japan," illustrated by colored slides. Having spent some months in Japan under government auspices, he was able to give a graphic account of Japanese woodworking technique. The closing event of the banquet was a sound film on "High-Frequency Heating," by the Westinghouse Manufacturing Corporation.

There were two technical meetings on Friday. The morning session provided a paper on on a "Development Center for Forest-Fire-Control Equipment" by Ira C. Funk, director of such a center at Arcadia, California, who outlined co-operative possibilities between the forest firemen and engineers. Mr. Funk's paper was published in the July, 1947, issue of MECHANICAL ENGINEERING.

Papers of distinct interest were presented by J. N. Tynan of A. G. Spalding & Bros. on "Laminated Tennis Rackets," and by O. S. Tuttle of the U. S. Plywood Corporation, on "Honeycomb Sandwich Construction." Both of these unusual wood products provoked active discussion, since they not only broaden the field of wood utilization, but provide products of improved physical characteristics. The honeycomb core, of impregnated paper in hexagonal cells, supplies an exceedingly rigid stressed skin panel that is phenomenally light in weight.

Reclamation of Sawdust

The afternoon and final session also provided three papers on diversified subjects. Roger R. Smith of the Pressed Wood Corporation of Greenfield, Mass., described the process of making small tool boxes of ground-wood aggregates with a resin binder. Samples were exhibited that withstood far more severe tests than solid wood in conventional form. The reclamation of sawdust and shavings has aroused widespread interest recently and Mr. Smith demonstrated an economical product in substantial production. E. George Stern of Virginia Polytechnic Institute at Blacksburg, Va., presented an abstract of rigid tests on a laminated flooring construction, sponsored by the T.V.A. The equipment developed turns out wide flooring boards on a continuous basis, and its durability was proved superior to conventional solid oak flooring. The final paper by E. C. Swanson of the Anderson Corporation of Bayport, Minn., presented the study of improved window-frame production, in which modern types of sash and frames are fully prefabricated in the factory.

1948 Conference Planned for October

The Wood Industries Division is planning to hold two sessions at the Annual Meeting of the A.S.M.E. in Atlantic City in early December.

The 1948 meeting may be a separate conference in October, held at some resort center where emphasis may be more evenly divided between social contacts and technical subjects.

Reported by THOMAS D. PERRY.

Graphic Arts Exhibit Announced

THE Photographic Group of the A.S.M.E. Metropolitan Section will hold a Graphic Arts Exhibit at the A.S.M.E. 1947 Annual Meeting, at Atlantic City, N. J., Dec. 1–5, 1947. All members and nonmembers are cordially invited to submit exhibits. Prizes will be awarded. For additional information write to Edward S. Rowell, The Babcock and Wilcox Company, 85 Liberty St., New York 6, N. Y.

Electrical Engineers Elect Officers

BLAKE D. HULL, chief engineer, Southwestern Bell Telephone Company, St. Louis, Mo., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1947, it was announced at the annual meeting of the Institute held in Montreal, Que., Can., June 11, 1947. Other officers elected were: vice-presidents, G. W. Bower, Haddonfield, N. J., J. H. Berry, Norfolk, Va., I. M. Ellestad, Omaha, Neb., D. I. Cone, San Francisco, Calif., D. G. Geiger, Toronto, Ont., Canada. Directors: W. L. Everitt, Urbana, Ill., A. C. Monteith, member A.S.M.E., East Pittsburgh, Pa., Elgin B. Robertson, Dallas, Tex. W. I. Slichter, Fellow A.S.M.E., professor emeritus of electrical engineering, Columbia University, N. Y., was re-elected treasurer.

Wide Range of Aviation Problems Discussed at A.S.M.E. 1947 Aviation Conference

RADAR as a system of commercial air safety, use of plastics as the solution to complex aircraft-design problems, the impact of guided missiles on military tactics, the building of the Northrop flying wing, and the obstacles to further increase in aircraft speeds, were among the subjects discussed at the 1947 Aviation Conference of the Aviation Division of The American Society of Mechanical Engineers, held at the University of California at Los Angeles, Calif., May 26 to 29, 1947. More than 1500 engineers attended 27 evening sessions and took part in discussion of 40 technical papers covering a wide range of engineering problems currently confronting the aviation industry.

Radar Is Not a Device

Radar is not a device but a technique which may take on a hundred different forms and be adapted to scores of different uses, L. A. Dubridge, president, California Institute of Technology, Pasadena, Calif., told the engineers at the opening session. Speaking on "Increased Safety in Aviation Through Radar," he said that with reference to air safety, radar must be considered in two ways. "We must think not only how it will help in existing standard operating procedures, but also how it will enable us to do things we can't do now," he said. "Secondly, we must think of radar not only by itself, but in relation to all other facilities. We need not a series of devices, but an integrated system" of air safety.

Referring to the aids to blind flying made possible by radar, Dr. Dubridge said that pilots prefer contact conditions. The pilot "wants to see the ground, see other obstacles and other planes, and he wants to see just where the landing field is ahead, where the mountains and coastlines and rivers are.

"When you want to see in the dark or through clouds and fog, radar can do it," he said.

"A small radar set for aircraft was developed during the war which will let the pilot see these things: his actual distance to the ground (altimeters don't always work!), obstacles ahead, the pattern of the terrain below, cities, rivers, mountains, airfields—even clouds and rainstorms which lie ahead. With the aid of radar beacons on the ground, his course can be clearly marked, obstacles labeled, airfields identified.

"Is such a set economical? I don't know and I'll let the accountants worry about that one. I only suggest that the cost of one or two canceled flights will probably pay for a set; the cost of one accident will equip a whole fleet."

Plastics in Aircraft

Speaking on "Plastics in Airframe Interiors," R. J. Considine, Douglas Aircraft Company, Inc., Santa Monica, Calif., described how plastics helped to solve problems involved in design of the window on the DC-6, the requirements of which were as follows: It had to withstand air loads and cabin pressurizing loads; it could not fog or frost over; it had to have good optical properties, be tough enough to withstand the deflections of the airframe, and handling in shop and storage.

"A research program was initiated and the various optical materials studied. The double-pane window was developed to prevent the fog and frost that normally forms on a single-pane window at high altitudes and obstructs the passengers' view. The application of the acrylics to the window design proved in test to be the material best able to withstand the air and pressurizing loads, coupled with the impact strength required to withstand the handling. The acrylics also supplied the required optical clarity."

Plastics also provided the answer to the problem of floor covering. This covering had to feel like a carpet. It had to be washable. It had to be replaceable. It had to have good wear resistance. It had to be attractive to the eye and finally it had to be fireproof. For this job, Mr. Considine said, the designers "selected from the known materials, the versatile vinyl chloride. It is tough! Tests indicated it can outwear truck tires ten to one (per the National Bureau of Standards wear tests). It is inherently fire-resistant. It can be manufactured in an infinite variety of colors. It resists water and solvents.

"The problem was to make the material look and feel like a carpet. The designers contacted the manufacturer and a fire-resistant neoprene foam applied as a backing to the vinyl floor covering was developed. The vinyl film was supported by cloth and was embossed to impart a texture to the surface. The neoprene was also backed with cloth and the assembly was laid on the floor with a mastic."

Guided Missiles

Experimental guided missiles now being built must have many improvements before militarily decisive weapons are available, according to H. J. Stewart, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif. Mr. Stewart spoke on "The Present Status of the Guided Missile." He said that the present status of the guided missile is analagous to that of the heavy bomber in 1919, but that "we need not expect a corresponding 25 years' development period for the guided missile, since the importance of a vigorous program has been recognized."

Northrop Flying Wing

The horizontal-jig assembly, the tools and methods for working the alloy 75S dural, involved in the building of the Northrop flying wing, were described by D. G. Leland, Northrop Aviation Corporation, Hawthorne, Calif., in his paper "Mechanics of Building the Northrop Flying Wing."

Mr. Leland traced the development of the Northrop flying wing from 1929 to 1941 when the preliminary design for the XB-35 was submitted to Wright Field. Preliminary production design began early in 1942 and approval of the mock-up was obtained in July of the same year.

"To provide flight research data, four scale models of the B-35 were built and flown," he said. "These models, designated N-9-M's, are twin-engine pusher type. They have a wing span of 60 feet and are approximately one third the size of the B-35's. The first three were powered with 275-horsepower Menasco engines. The fourth model was powered with two 300-horsepower Franklin engines." Major components of the Northrop flying wing were assembled in a horizontal final assembly jig, with the horizontal-wing reference water line parallel to the ground. According to Mr. Leland, this decision was reached primarily

SOME OF THE MEMBERS OF THE 1947 AVIATION CONFERENCE COMMITTEE
(*Left to right:* Ernest Hartford, J. C. Dillon, William Schroeder, J. Calvin Brown, vice-president, A.S.M.E. Region VII, W. E. Mason, Timothy E. Colvin, and W. L. Orr.)

E. H. HEINEMANN, CHIEF ENGINEER OF THE SEGUNDO PLANT OF THE DOUGLAS AIRCRAFT COMPANY, WHO SPOKE ON HIGH-SPEED AIRCRAFT DEVELOPMENT AT THE 1947 AVIATION CONFERENCE

because: (1) the number of airplanes to be built did not warrant the expense of an extensive program of master tooling and matched subassembly jigs; (2) the size of the wing made it appear impractical to assemble it in a jig with the leading edge down and the horizontal reference line perpendicular to the floor; (3) the experimental nature of the project made it desirable that the final assembly sequence and jig construction permit as much flexibility as possible; (4) and the problem of removing the finished wing from the jig also influenced the decision to assemble it in a horizontal position.

Mr. Leland said that the use of 75S dural caused the most trouble at the start of the project since there was practically no information available regarding its formability in the various tempers.

"The first thing we discovered when we received sheets of material for test," he said, "was that none of our manufacturing standards which had been established for 24S-T would produce satisfactory parts in 75S-T."

Northrop had to embark upon an extensive research and test program to determine just what would give satisfactory results. This finally involved changing practically all of their standard forming tools to allow for larger bend radii.

High-Speed Flight

In his paper "High-Speed Aircraft Development" E. H. Heinemann, chief engineer, Douglas Aircraft Company, told the meeting that the development of rockets as uninhabited missiles capable of being fired to any point on the face of the earth appears to be within the realm of possibility, and that the problems of satisfactory guidance and control are now considered to be the greatest unsolved problems in this field.

In the 44 years since the Wright Brothers' first flight, Mr. Heinemann pointed out, airplane speed has advanced at the rate of 14 miles per hour per year. This applies to top speeds. Air-transport cruising speeds have been increasing about one half the speed of record-breaking airplanes or 7 miles per hour per year. In 1946 the gain in top speed was only 10 miles per hour.

Among the problems which must be overcome to attain higher speeds, Mr. Heinemann listed the following: shock waves caused by compressibility of air; new power plants to meet the abrupt increase of power required with increase of speed; atmospheric considerations introduced by high-altitude flight; high-temperature effects on structures and equipment caused by aerodynamic heating.

Mr. Heinemann's paper will be published in an early issue of MECHANICAL ENGINEERING.

Petroleum Committee Plans National Conference in Houston, Texas

THE A.S.M.E. 1947 National Conference on Petroleum Mechanical Engineering will be held at the Rice Hotel, Houston, Texas, Oct. 6 to 8, 1947. The conference is to be the second conducted by the Petroleum Committee of the Process Industries Division of The American Society of Mechanical Engineers, since its organization in 1944.

Besides the technical sessions, the program will include social events and several inspection visits to points of engineering interest.

A registration fee of $6 will be charged to members and $10 to non-members. The registration fee will cover the cost of conducting the conference as well as publication of the conference proceedings, a single volume containing all papers presented, to be distributed to all who register.

The Proceedings of the 1946 National Conference is a 220-page volume containing 36 papers and more than 300 illustrations. Copies of the volume currently being distributed to registrants of the 1946 Conference, may be obtained at $4.50 a copy, from the Sales Department, A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y.

Local arrangements for the conference will be in charge of the A.S.M.E. South Texas Section from which G. W. Lowther, Texas Gulf Sulphur Company, Newgulf, Texas, has recently retired as chairman. Both he and M. I. Kearns, Brown and Root Inc., Houston, Texas, chairman of the Section, have contributed much to the success of the conferences of the Petroleum Committee.

The conference will treat the mechanical-engineering problems of the petroleum industry under four headings: manufacture of equipment, materials, refining, and petroleum transportation.

Papers covering such subjects as accessories for good operation of pressure-storage vessels, investigation of stress in vessels under internal pressure, a study of tube rolling, and hydraulic pump for shallow oil wells are among those listed for the equipment-manufacturers' session.

For engineers concerned with materials used in the industry, the materials sessions will offer papers on a study of weldments in alloy steels and a history of some austenitic (19-8) furnace tubes. There will be a paper on the application and handling of foams, and another reporting on corrosion by distillate wells.

Four papers are planned for the petroleum-refining sessions. These will cover such subjects as internally insulated piping for high-temperature service, field welding and stress relieving of alloy piping and others.

Problems involving transportation of petroleum products also will be discussed.

William Raisch, consulting engineer, New York, N. Y., is chairman of the Petroleum Committee, E. W. Jacobson, Gulf Research and Development Company, Pittsburgh, Pa., is secretary. Other members are: E. N. Kemler, chairman, production engineering subcommittee, professor of mechanical engineering, New York University, New York, N. Y.; P. E. Frank, chairman, refining subcommittee, Sinclair Refining Company, New York, N. Y.; B. B. Morton, chairman, materials subcommittee, International Nickel Company, New York, N. Y.; C. L. Pope, chairman, applications subcommittee, Eastman Kodak Company, Rochester, N. Y.; J. M. Sexton, chairman, manufacturers subcommittee, M.W. Kellogg Company, New York, N. Y.; and R. B. Tuttle, chairman, special committee on papers and publications, Tulsa, Okla.

The tentative program of the Conference will be published in the September issue of MECHANICAL ENGINEERING.

A.S.M.E. Calendar

of Coming Events

Sept. 1–4, 1947
A.S.M.E. Fall Meeting
Salt Lake City, Utah

Sept. 8–9, 1947
A.S.M.E. Instruments and Regulators Division Meeting
Chicago, Ill.

Oct. 6–8, 1947
Petroleum Committee of the A.S.M.E. Process Industries Division Meeting
Houston, Texas

Oct. 20–22, 1947
A.S.M.E. Fuels Division Meeting
Cincinnati, Ohio

Dec. 1–5, 1947
A.S.M.E. Annual Meeting
Atlantic City, N. J.

March 1–6, 1948
A.S.M.E. Spring Meeting
New Orleans, La.

May 30–June 5, 1948
A.S.M.E. Semi-Annual Meeting
Milwaukee, Wis.

Sept., 1948
A.S.M.E. Fall Meeting
Portland, Ore.

Nov. 28–Dec. 4, 1948
A.S.M.E. Annual Meeting
New York, N. Y.

Meetings of Other Societies

August 7–8
Institute of the Aeronautical Sciences, Inc., Annual Summer Meeting, Los Angeles, Calif.

August 26–29
American Institute of Electrical Engineers, Pacific general meeting, San Diego Hotel, San Diego, Calif.

September 3–6
Technical Association Pulp and Paper Industry, fundamental research meeting, Institute of Paper Chemistry, Appleton, Wis.

September 8–12
Instrument Society of America, second annual conference and exhibit, The Stevens Hotel, Chicago, Ill.

September 15–19
American Chemical Society, 112th national meeting, New York, N. Y.

September 17–18
Society of Automotive Engineers Inc., national tractor meeting, Hotel Schroeder, Milwaukee, Wis.

September 17–26
National Machine Tool Builders' Association, machine-tool show, Dodge Chicago Plant, Chicago, Ill.

September 22–25
Association of Iron and Steel Engineers, annual meeting, Hotel William Penn, Pittsburgh, Pa.

September 29–October 1
American Institute of Chemical Engineers, regional meeting, Hotel Statler, Buffalo, N. Y.

October 2–4
Society of Automotive Engineers, Inc., national aeronautic meeting and aircraft engineering display, Biltmore Hotel, Los Angeles, Calif.

October 6–8
American Gas Association, annual meeting, Cleveland, Ohio

October 6–10
National Safety Council, Inc., 35th national safety congress and exposition, The Stevens and Congress Hotels and the Palmer House, Chicago, Ill.

October 15–17
American Society of Civil Engineers, fall meeting, Jacksonville, Fla.

Cornish Engine Preserved by Dutch Engineers

ONE of the Cornish pumping engines purchased by the Netherlands Government in 1840 for service in the Haarlem Meer section of Holland, southwest of Amsterdam, has been preserved by the Cruguis Vereeniging, a Dutch society organized in 1933 for the purpose of taking over the pumping property about to be retired after more than 80 years of continuous service.

This information was furnished by C. G. Hartland of Voorburg, Holland, who found reference to the Haarlem Meer engine in James T. Kemp's article "Preserving the Cornish Engine," published in the May, 1947, issue of MECHANICAL ENGINEERING.

In his letter Mr. Hartland said that "the engine complete with its original building and the water pumps constitute a museum which attracts many visitors, especially students." The museum came through the war without damage.

In designing the pumping equipment for the Haarlem Meer plant, the British designers, A. Dean and G. Gibbs, had to adapt machinery originally developed for deep pumping to meet the low-head conditions of Holland. This they did by surrounding the engine with a ring of eight pumps each operated by its own walking beam. The pumping station is a circular building through which huge walking beams protrude. The pump cylinders are located outside the building within a walled courtyard which circles the enginehouse. Operating at a steam pressure of 40 to 45 psi and at 5 to 7½ rpm, the Haarlem Meer engine could develop 274 hp.

Practicing Engineers Advise Faculty

THE A.S.M.E. North Texas Section and other local sections of professional societies in Dallas, Texas, have established committees to advise the Southern Methodist University, Dallas, Texas, on matters of engineering education. The purpose of the committees is to pass ideas from practicing engineers to those who teach and to provide counsel on other matters affecting engineering curriculum.

The A.S.M.E. committee, appointed at the request of Ray M. Watson, member A.S.M.E., professor of mechanical engineering, Southern Methodist University, is composed of the following: W. B. Gregory, member A.S.M.E., assistant manager, A. M. Lockett and Company, Ltd., Dallas, Texas; Harry Pearson, member A.S.M.E., personnel director, Dallas Light and Power Company, Dallas, Texas; and Clifford Cowles, member A.S.M.E., Cowles and Company, Dallas, Texas.

On April 16, 1947, the curriculum committees of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the Society for the Advancement of Management, and the A.S.M.E. met at the Baker Hotel, Dallas, Texas. Following the dinner, three departmental sessions were held during which views were exchanged on changes in the postwar curriculum.

So much interest was shown by engineers on the various committees that it was decided to call the group together several times each year on educational matters affecting the engineering profession.

New Organization to Serve Inventors and Industry

THE organization of a National Foundation for Science and Industry as an Illinois nonprofit corporation to serve as a clearinghouse of new ideas between inventors and industry, has been announced.

The Foundation publishes a monthly digest of patented ideas and those for which patents are pending. Subscription rate is $25.

As a nonprofit organization all funds over actual operating expenses will be used to stimulate creative thinking and to aid inventors. The Foundation intends to press for changes in the Federal tax structure to aid new industries and to oppose the compulsory licensing of patents.

Additional information may be obtained from the National Foundation for Science and Industry, 203 North Wabash Avenue, Chicago, Ill.

Joint Fuels Conference to Be Held in Cincinnati Oct. 20–22, 1947

THE Tenth Joint Fuel Conference of The American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers will be held at the Hotel Gibson, Cincinnati, Ohio, Oct. 20–22, 1947.

The program includes nine papers covering information on the top problems both in the production and in the utilization of coal. Several luncheons and dinners are also planned at which prominent speakers will discuss topics of national interest.

A feature of the conference will be the complete report on the underground-gasification experiment at Gorgas, Ala.

The problem of improved preparation will be covered by a report on "The Dorrance Colliery Cleaning Plant," reputedly the largest coal-cleaning plant in the United States, as well as a report on "Further Tests of Dutch Cyclone Coal Washer."

The A.I.M.E. Preparation Committee will report on the "Estimates of Moisture Increase Due to Water Spraying Coal for Dust Control." The same session will include a paper on "Sectionalizing Power Distribution Underground."

The "Design and Operation of Small Coal-Fired Boiler Plants," a subject which has been badly neglected in the literature, will be covered by a panel of outstanding experts in this field.

The problem of atmospheric-pollution reduction is becoming more and more important to the coal industry every day.

Two papers will be given which discuss the important but little-recognized influence of the meteorological phenomena on atmospheric pollution.

MEMBERS OF THE EXECUTIVE COMMITTEE OF THE A.S.M.E. CENTRAL IOWA SECTION EXAMINE SOME OF THE DEVELOPMENTS IN FLUID SEALS MADE BY THE MAYTAG COMPANY

(*Left to right:* E. D. Hay, George Hill, M. P. Cleghorn, T. R. Smith, speaker, G. D. Boylan, J. F. McLaughlin, and John Symons.)

Sections

Connecticut Sections Hold Joint Meeting

Th annual meeting of the Connecticut Sections was held May 24 at Ocean Beach Park, New London, Conn. The New London Section was host for the first time in ten years, to 100 engineers, their wives, and friends, from Fairfield County, Hartford, New Haven, Waterbury, and New London. In the afternoon about 50 guests visited the U. S. Submarine Base in Groton, and the Mystic Marine Museum in Mystic. Matters concerning engineers and the education of engineers were discussed in a meeting of the General Committee of which Prof. K. P. Hanson is chairman. At the dinner the toastmaster was Prof. C. H. Coogan, who called on L. A. Lachman, chairman, New London Section, for a few words of welcome. Alton C. Chick, vice-president, A.S.M.E. Region I, presented certificates of recognition to past-chairmen. Speakers were Miss Vivien Kellems, president, Kellems Company, Saugatuck, Conn., and Dr. Augustus Klein, engineering manager, Stone & Webster Engineering Corporation. Miss Kellems spoke on" Woman's Place in the Modern Industrial World." She stressed the contributions made by women in the last decades and the struggle to gain equal rights under the law for women. Dr. Klein lectured on the atomic-bomb test at Bikini. He directed the construction of the pilot plants for atomic power and the Oak Ridge project. He described in detail the object of the test, the enormous amount of technical work preceding and following the test, and the fearful destruction wrought by the bomb. An official technicolor film of the Bikini tests illustrated the lecture.

Central Iowa Section Announces New Officers

The last meeting of the season was held on May 7 at the Maytag Hotel, Newton, Iowa. This combined an inspection trip and dinner meeting. A tour of the Maytag manufacturing plant and research laboratories was made in the afternoon, followed by dinner, the latter attended by over 100 members and guests. T. R. Smith, director of research and development of the Maytag Company, gave an illustrated talk on Maytag Hydraulic Seal Development.

The new officers for the coming year are: Glen D. Boylan, chairman; Merlin Hansen, vice-chairman, and Earl D. Hay, secretary-treasurer.

Metropolitan Section Meets at La Guardia Airport

Four hundred members of the A.S.M.E. Metropolitan Section took advantage of an opportunity to visit behind the scenes at La Guardia Airport, New York, N. Y., on June 12, 1947. The arrangements were made by Roland W. Flynn, past-chairman of the section in co-operation with the American Airlines. Following a trip through the hangars and repair and maintenance shops, members were taken aloft to get a view of the city from the air.

Originally six flights were scheduled but when the registration approached the 400 mark, a seventh flight was added. Starting from the field, the planes flew across the upper end of the city, down around the Statue of Liberty, back up the Hudson, and over the new Idlewild Airport.

The flights were carried out at an elevation of 2000 feet and at a speed of 210 miles an hour. Many of the passengers were making their first trip in the air. The sight of New York from "upstairs" is always inspiring, even to those who have seen it a number of times.

The trip through the hangars was highlighted by a close-up view of DC-4 and Constellation planes which from the ground are almost overpowering in size. In the shops the guests were able to witness the actual operations necessary to the maintenance of the planes. Besides repair work, the American Airlines carry on some manufacturing processes of parts so that the efficiency rating is high.

A reception was held in the Terrace Dining Room following the flights and inspection trips. President Eugene W. O'Brien was the honored guest at the reception. While at La Guardia Field, President O'Brien presented Certificates of Award to Roland W. Flynn, A. R. Mumford, C. A. Hescheles, N. C. R. Carlson, W. H. Larkin, and J. N. Landis, for outstanding committee work in Section activities. Four of the group are past-chairmen of the Section.

PRESIDENT O'BRIEN VISITS METROPOLITAN SECTION

(*Left to right:* H. R. Kessler, chairman, A.S.M.E. Metropolitan Section, E. W. O'Brien, president A.S.M.E., and Herbert Lyall, American Airlines, chairman of the Aviation Section of the New York Board of Trade.)

Mid-Continent Section Closes Season

The annual dinner of the Section was held on May 1 at Tulsa, Okla. Wick Fowler, war correspondent for the *Dallas News*, was the speaker. Mr. Fowler went through many campaigns of the African, Italian, and European fronts, and later went to the Pacific front. From them he brought many reminiscences, some humorous, some pathetic, mingled with thought-provoking comments and observations.

The final meeting of the year was held June 12, in the Oklahoma Room of the Tulsa Hotel, Tulsa, Okla. The speaker was Morris Frack, formerly a member of the A.S.M.E., and his subject was "The Engineering Aspects of Patent Applications."

Piedmont Section Host to A.S.M.E. President

On June 6 at the Hotel Charlotte, Charlotte, N. C., a noon luncheon meeting was held at which the speaker was William H. Neal, senior vice-president of the Wachovia Bank & Trust Company, Winston-Salem, N. C. Mr. Neal declared that a decrease in governmental expenses, a cut in taxes, and a gradual reduction of prices were "musts" if this country is to "lead the world back to economic sanity and stability." There were 100 at the luncheon. In the afternoon an inspection trip was made to the Lance Packing Company in Charlotte, N. C. At the dinner given the same evening, 150 came to hear Eugene W. O'Brien, president A.S.M.E., speak on the position of youth in southern industry. President O'Brien said that the South has shown the fastest industrial growth any section of the country has ever experienced, and he predicted that the growth will continue for a long time. Members of the Greenville and Raleigh Sections attended the one-day meeting.

Dinner Meeting at Western Washington Section

On June 4 at the Faculty Club, University of Washington, Seattle, Wash., an audience of 80 heard Prof. F. Burt Farquharson of the University of Washington, discuss "Europe" and "New Testing Laboratory, Civil Engineering Department, U. of W." The speaker told very interesting experiences of his recent trip to Europe for engineering conferences in France and England. Most important were his contacts with British suspension-bridge builders, as the British are foremost authorities on bridges. After the dinner and talk, Professor Farquharson conducted a tour through the University's new testing laboratory, where the visitors saw a model of a suspension bridge for Tacoma Narrows. A $2^1/_2$-million-lb testing machine was demonstrated with a compression specimen. A calibration ring was demonstrated in a 100,000-lb machine.

Bikini Films Shown at Southern Tier Section

Before a group of 135 engineers and their guests from other technical societies, Jack Bousman, engineer from General Electric Company, showed and narrated the color film, "Bikini Atom Bomb Test" to the Southern Tier Section of The American Society of Mechanical Engineers on Monday evening June 30, 1947, in the New York State Institute of Applied Arts and Sciences Building, Binghamton, N. Y.

Mr. Bousman, who was present at Bikini, turned off the sound track on the film and told of his personal experiences. He also impressed his listeners with the effects of the atom bomb if exploded over a typical American city.

After the showing of the films, guests were shown the facilities of the Institute and were told of future plans of its directors.

The meeting committee consisted of Joseph Mazzola, Cecil C. Tyrrell, and Morton L. Kaganowich.

Southern California Section Reports Three Meetings

On May 15 the Plastics Division of the Section held a joint meeting with the Society of the Plastic Industry, in the Rodger Young Auditorium, Los Angeles, Calif. The speakers and their subjects were: Wm. J Dewar, assistant technical director, Plastics Industries Tech. Institute, "Compression and Transfer Moldings of Thermosetting Materials;" Clinton C. Booth, sales engineer, Glen H. Taylor Company, "Plastic Laminates;" T. W. Kerr, superintendent, Plastic Process Company, "Extrusion Moldings of Thermoplastic Materials;" John L. Taylor, president, Alladin Plastics, Inc., "Injection Moldings of Thermoplastic Materials."

On June 3 in the Bovard Auditorium, University of Southern California, Los Angeles, Calif., B. R. Prentice, staff engineer, General Electric Company, spoke on "Atomic Power Plants." This was a joint meeting with the Los Angeles Engineering Council and the University of Southern California engineering departments. Mr. Prentice discussed recent developments and activities of his company in the atomic power field and possible use of atomic power plants. There were 873 present.

The meeting on June 19 featured Otto de Lorenzi, member A.S.M.E., director of education, Combustion Engineering Company, Inc., New York, N. Y., who spoke on "Methods of Burning Liquid and Gaseous Fuels." He explained the various types of combustion burners and fuels and illustrated with motion pictures in kodachrome the turbulence and combustion obtained by the various methods. Eighty-seven were in the audience.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEER, B.S.E.E. and B.S. M.E., age 26, married. Four years' experience in research, engineering, and administration. Desires administration or engineering in Southwest. Available immediately. Me-201.

GRADUATE AERONAUTICAL ENGINEER, age 21, single. Nine months' experience in design and layout work in aeronautical field. Desires position in aeronautical, mechanical, or industrial engineering. No objection to traveling. Me-202.

ENGINEER, interested in high-quality-product design, inventive with shop ability and a background in industrial design, M.E. degree, five years' professional experience. Seeks opportunity in consumer product or allied field. Me-203.

MECHANICAL ENGINEER, 32, M.I.T. graduate, desires permanent position with a progressive firm where mathematical and analytical ability in engineering is a distinct advantage. Six years' experience in designing, servicing, and stress and vibration analysis in power-equipment manufacture and chemical industry. Eastern location preferred. Me-204.

[1]All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

ENGINEERS. (*a*) Maintenance engineer, mechanical graduate, 35–45, with three years, experience in chemical plants on design, operation, and preventive maintenance of steam

plant of modern design, also general chemical-plant-maintenance experience. Salary open. (*b*) Maintenance engineer, 35–45, mechanical graduate, with over three years' experience, for maintenance of plants including steam plant. Should have some refrigeration experience. $4800–$6000. Connecticut. W-9225.

PRODUCTION CONTROL SUPERVISOR, capable of over-all production planning, scheduling; supervision of heavy-machine-tool manufacturing, including knowledge of inventory control, purchasing co-ordination, scheduling fabrication of parts, and purchases; methods and routing, machine and man-hour standards. Department must be largely set up, organized, and supervised. Shop personnel about 125 employees. $5000. Southern Connecticut. W-9228.

ENGINEERS. (*a*) Design engineer, mechanical graduate or one having experience in design of hermetic compressors of capacities from fractional and small-integral to five tons refrigeration. (*b*) Heat transfer specialist, engineering graduate, preferably with graduate work in heat transfer. To work on applied research and improvement of heat-transfer equipment. Upon completion of applied research projects will be required to work on general assignments; (*c*) Sound and vibration engineer to work on compressor and air-conditioning-equipment studies and capable of organizing test programs which will include special instrumentation. Upstate New York. W-9246.

MECHANICAL ENGINEER, graduate, 27–35, with several years' experience in mechanical maintenance. Must be able to supervise building maintenance and small boiler operations. Write giving details and salary desired. Pennsylvania. W-9258.

ENGINEERS. (*a*) Chief mechanical design engineer to head up division of utility company. Must have ten to fifteen years' steam-power-station-design experience. $6500–$7000. (*b*) Project engineer, mechanical, with similar background as above. $5000–$6000. Pennsylvania. W-9265.

SALES MANAGER, engineering graduate, with at least ten years' experience in sale of steam-power-generating equipment. Salary open. Pennsylvania. W-9275.

MECHANICAL ENGINEER, 26–30, graduate, with 4 to 5 years' experience for work on air conditioning, machine design, piping, automatic controls, elementary structures, steam and power utilization, and process equipment for textile company. Must be able to prepare reports and supervise maintenance labor. Northern New Jersey. W-9282.

MECHANICAL ENGINEER, graduate, under 45, with about ten years' general plant-engineering experience, to maintain close liaison with plant management and act as technical adviser to plant engineer; supervise engineering projects, including plant layout, process-equipment installations, some design, etc., for manufacturer of rubber products. $4500–$4800. Northern New Jersey. W-9284.

TEACHING PERSONNEL. (*a*) Instructor or assistant professor of mechanical engineering, preferably with M.S. degree, to teach fundamental mechanical-engineering subjects in the classroom and laboratory. $2400. (*b*) Assistant associate professor of mechanical engineering, M.S. degree, to teach advanced and elementary undergraduate courses. About $3000. Vermont. W-9295.

MACHINE DEVELOPMENT ENGINEERS, 28–44, mechanical graduates, with 5 to 10 years' diversified engineering experience, at least two years of machine drafting and design work on the board; two years in machine shop and some time spent on experimental engineering, machine development, and mechanical research. Salaries open. Delaware and New York, N. Y. W-9303.

SALES ENGINEER, 30–35, with engineering education and experience with steam-power-plant equipment. Should have ability to learn quickly how to prepare and submit proposals on boilers and complete steam-generation equipment. Will have to travel and assist in selling such equipment. Salary open, Pennsylvania. W-9312.

INSTRUCTORS, engineering graduates, with two to three years' experience in industry and general background in production control and jig and tool design. $3200–$3600 a year. Pennsylvania. W-9313.

PRODUCTION ENGINEER, 38–45, with a background of successful management experience in a first-rate manufacturing company, preferably in the manufacture or converting of paper products, for expanding manufacturing organization. Salary open. Pennsylvania. W-9317.

MECHANICAL ENGINEER, not over 35, for technical service on machining of alloys. Should be familiar with shop practices on grinding, press work, and spinning, and be capable of handling design and solving of general mechanical-engineering problems. Occasional travel. Will be trained. Write giving full educational and professional records and salary expected. New York, N. Y. W-9320.

CHIEF ENGINEER, under 45, mechanical graduate, with at least ten years' paper-mill experience, to take general charge of mill maintenance and construction and in particular to be responsible for plant layouts, process planning, and projects studies covering paper making, finishing, printing etc. $8000–$10,000. New Jersey. W-9321.

ENGINEERS. (*a*) Advisory mechanical engineer, under 40, preferably single, for liaison work on plant layouts, selection of equipment, methods of local construction, production, and purchasing. Three-year contract. $4200–$5400. In some cases cost-of-living allowance. Location foreign. (*b*) Advisers, mechanical engineers, for domestic office, for similar work. Salary open. New York, N. Y. W-9332.

PLANT ENGINEER, under 40, with at least three years' maintenance experience, preferably on textile-mill equipment. Company operates nine mills in Pennsylvania, Virginia, and North Carolina. $6000–$7500. Headquarters, Pennsylvania. W-9342.

MECHANICAL OR CHEMICAL CONSTRUCTION ENGINEER, 40–45, with at least ten years' installation experience, to take charge of equipment erection in chemical-processing plant. Must have had considerable experience in New Jersey. $5000–$6000. Northern New Jersey. W-9352.

SENIOR MANAGEMENT SUPERVISOR, business-administration graduate, with four years' experience in administrative or supervisory capacity in a commercial chain retail-variety-store organization, or three years in a similar capacity in Army exchange operation, to direct work of junior management supervisors in surveys, writing of reports including findings and recommendations. $5220. New York, N. Y. W-9358.

ENGINEERS. (*a*) Mechanical engineer, full professor interested in research with sufficient technical training to handle graduate courses, including supervision of research projects carried on by advanced students, as well as teaching some junior and senior courses. General fields will be heat and engineering materials. Northwest. $5400–$6000 for 9½ months. (*b*) Instructor for mechanical-engineering department, with an opportunity to do some research if interested. Subjects could be arranged, as schedule and faculty are flexible. Prefer a man with M.S. degree, with, or without experience. $3300–$3700 for 9½ months. (*c*) Research engineers, one for planning and carrying on research in the field of wood technology for department of industrial reseach and one interested in and qualified to carry on research in ceramics, involving a study of the clays of the state. $4500–$5000 for 9½ months. R-4265.

New Fellowships Announced

TWO fellowships, one in petroleum-production engineering, and the other in the metallurgical, mechanical, and chemical properties of wire as they pertain to the weaving of industrial wire cloth, have been announced by the Missouri School of Mines and Metallurgy, Rolla, Mo.

The Shell Union Oil Corporation fellowship provides a stipend of $1200. The Ludlow-Saylor Wire Conpany fellowship carries a stipend of $1500. Applicants for the academic year beginning Sept. 1, 1947, should write to Dr. J. D. Forrester, Missouri School of Mines and Metallurgy, Rolla, Mo., for information.

Both fellowships offer opportunity for renewal for more than one year. Doctorate candidates will be given preferential consideration.

Metropolitan Section Fall Review Courses

THE Metropolitan Sections of the A.S.M.E. and the A.I.E.E. announce the Fall program of Review Courses designed to prepare engineers for New York and New Jersey professional engineer's license examinations.

The following courses will be given: Engineering Economics and Practice, Structural Planning and Design, Effective Speaking, Mechanical Engineering, Electrical Engineering and Applications, and Basic Engineering Sciences.

Courses commence Sept. 3, 1947.

For folder write to The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.